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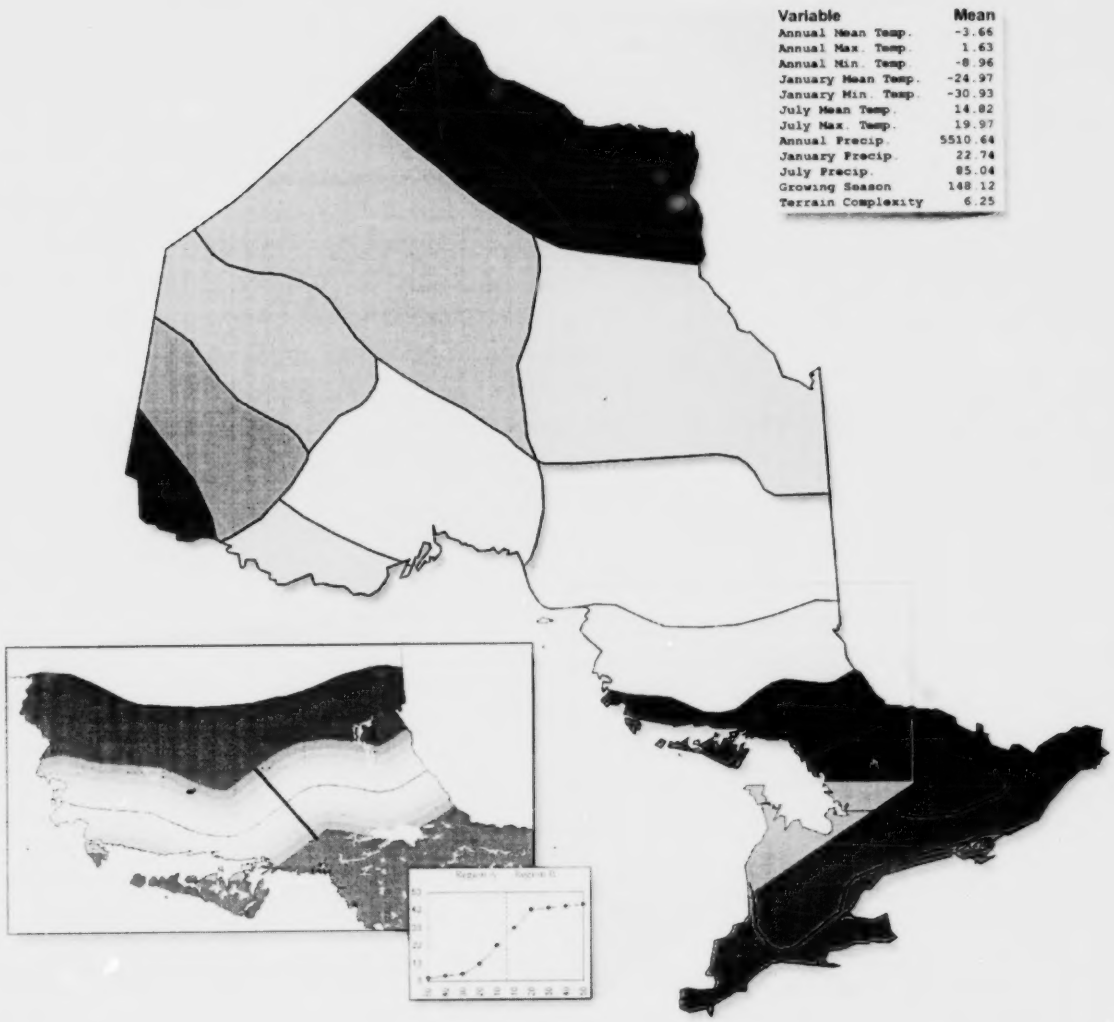
A Quantitative Basis for Using Ontario's Existing Ecoregionalization Systems



Ministry of Natural Resources

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A Quantitative Basis for Using Ontario's Existing Ecoregionalization Systems

by

David J.B. Baldwin
Lawrence E. Band
Ajith H. Perera

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Ontario Forest Research Institute
Ontario Ministry of Natural Resources
1235 Queen Street East
Sault Ste. Marie, Ontario
P6A 2E5

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Ontario Forest Research Institute
Ministry of Natural Resources
1235 Queen Street East
Sault Ste. Marie, Ontario
Canada P6A 2E5

Telephone: (705) 946-2981
Fax: (705) 946-2030
E-mail: ofriin@gov.on.ca

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Abstract

A quantitative basis was developed for using 3 existing terrestrial ecoregionalization systems in Ontario. Our objective was to quantify these systems using a multivariate set of geoclimatic variables and to determine their effectiveness in stratifying different ecological conditions in the province. We provide descriptive statistics and principal components analysis of each regional unit, compare multivariate distances and geologic similarity among units, as well as examining the gradients of geoclimatic variables across the unit boundaries. No system was superior overall; each showed strengths and weaknesses in delineating groups of variables (temperature, precipitation, geology, terrain). The usefulness of these systems depends on how well user goals are defined. New reproducible systems are needed.

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Introduction

Ecoregionalization is a crucial first step in resource management (Hills 1959, Burger 1986, Bailey 1988). Ecoregionalization systems stratify terrestrial or aquatic ecosystems, and attempt to simplify ecological complexity. These systems provide an ecologically based alternative to arbitrary administrative planning units and a logical basis for:

- planning for regional forest resources
- planning for protected areas
- assessing biodiversity
- monitoring ecosystems
- stratifying sample areas

A number of ecoregionalization systems and subsequent modifications have been developed for Ontario (Hills 1959, Rowe 1972, Wiken 1979, later mapped by Wickware and Rubec 1989, Burger 1986, Ecological Stratification Working Group 1995). Hills Site Regions (1959), the Terrestrial Ecoregions of Ontario (mapped by Wickware and Rubec 1989) and the Revised Terrestrial Ecoregions of Ontario (Ecological Stratification Working Group 1995) are the most extensively used terrestrial-based systems. The Hills system continues to play an important role in forest management (OMNR 1996), parks planning (OMNR 1997) and biodiversity and landscape pattern assessment (Perera and Baldwin 1993, Perera et al. 1994a). The 2 federal systems are used extensively to place provincial resources in a national context (Environment Canada 1991, 1996).

Despite their importance and quality of construction at the time they were developed, these systems have some important limitations, including:

- qualitative and poorly documented construction methods
- varying underlying objectives (timber, physiography)
- lack of reproducibility
- lack of flexibility to meet changing data and needs.

In light of these limitations, particularly the fact that they are not reproducible and there is no systematic way to customize or maintain them, basic quantitative knowledge of what each unit and boundary means in relation to geoclimatic variables is essential to their continued use.

The goal of this study is to provide a quantitative basis for the intelligent use of these existing systems by planners and resource managers. The specific objectives are:

- To use geoclimatic variables important to basic ecosystem functions to quantify each system and provide baseline knowledge of its structure
- To compare the system's strengths and weaknesses with respect to these variables or groups of variables (i.e., climate versus landform) and illustrate which variables can be delineated most effectively by each system at each location
- To examine the implications of the use of these systems by land and resource managers and the need for future regionalization work.

1.1 Background of the Ecoregionalization Systems

This study examines the regional-level units of the 3 ecoregionalization systems available for Ontario. For simplicity, Hills' Site Regions will be referred to simply as Hills, the Terrestrial Ecoregions of Ontario will be referred to as TEO, and the Revised Terrestrial Ecoregions will be referred to as RTEO.

1.1.1 The Hills System

The Hills system is undoubtedly the most important work in the field of ecosystem regionalization in Ontario. The goal of this

system was to classify the province into zones of biological productivity; in this case, productivity is defined in the context of forest crop production (Hills 1959). This regionalization was developed with a strong focus on landform and climate attributes and their relationship to vegetation response and succession. Hills proposed that landform provides the reference base to measure changes in climate and vegetation. The extent that climate is effective in vegetation control is determined by landform in terms of continentality and local expression of slope and aspect (Hills 1959).

To define the site regions, Hills started with a map of landform divisions based on broad relief features, broad bedrock classes and depth and texture of unconsolidated material. Forest associations occurring on these landform types were compared through reference study areas for each landform, supplemented by field examinations of a wide range of conditions (Burger 1993). Landform-vegetation succession patterns were established for the landform units. The site regions were then drawn using these vegetation relationships, incorporating climate gradients and airmasses, soil development gradients, and land use. The exact method that Hills used is vague; we can assume that it was a very subjective process given the quality of the map inputs available at the time. Hills suggested that drawing a site region line between 2 distinct vegetation succession patterns on the same landform was actually delineating regions of different "effective" climate (Hills 1959).

Even with the project's timber-oriented mandate, Hills recognized the need to delineate areas that defined more than simply which forest types grow where. He stated that:

"Using the succession of vegetation on specific landform conditions as indicators of effective climate, site regions are macroclimatic regions in addition to being landform and forest regions.

Since landform, climate, and vegetation constitute the habitat of animal communities, site regions are biotic regions (or biomes) refined on the basis of significant physiographic controls.

Since a site region is the integration of all the landscape features within a prescribed area, it can be best defined as 'a region of potential biological productivity'." (Hills 1959)

This system forms the basis of most ecologically based planning in the province and is still in use today. It was also a critical reference in the development of both the TEO and RTEO systems.

1.1.2 The TEO System

The regions developed by the TEO system were defined as "areas of land characterized by a distinctive ecological response to climate as expressed by the development of vegetation, soils, water and fauna" (Burger 1993). There is little documentation of the exact construction methods of this system. The most notable addition in developing this system was the incorporation of LANDSAT mosaics. Ecodistrict-level units were mapped from mosaics reflecting patterns of hydrology, geology, landform, vegetation, and topography (Burger 1993). The regions were developed by overlaying Hills system regions and adjusting them to reflect the new ecodistrict boundaries. The major differences among the systems are found where physiographic boundaries superseded the Hills vegetation-site relationship delineations.

1.1.3 The RTEO System

The RTEO system is a modification of the TEO system. Regions were defined by the Ecological Stratification Working Group (1995) as "subdivisions of ecozones characterized by distinctive large-order landforms or assemblages of regional landforms, small order macro or mesoclimates, vegetation, soils, water, and regional human activity patterns/uses". Again, the details about its construction are not well documented, but LANDSAT mosaics were incorporated and boundary lines were fit to the Soil Landscapes of Canada units (Ecological Stratification Working Group 1995).

CHAPTER 2

Methods

This chapter outlines the detailed methods used to quantify the ecoregionalization systems. The results of these analyses are presented in Chapter 3.

2.1 Geoclimatic Variable Selection

Previous studies were examined to identify variables that drive basic terrestrial ecosystem processes and to estimate the spatial scales at which these variables influence such processes. This helped to screen out attributes relevant to lower levels in an ecoregional hierarchy.

There is broad consensus in the literature that basic ecosystem processes are based on some combination of energy flows controlled by climate, terrain, and soil properties (e.g., Hills 1959, Zak et al. 1986, Bailey 1988, Russell and Jordan 1991, Kellomäki et al. 1992). The following section examines primary attributes in each of these categories that have been identified as important to ecosystem function through theoretical and empirical study. This section also outlines the datasets used to represent these variables and where data were lacking. Derived variables were avoided wherever possible to limit subjectivity, combination errors, and excessive correlation among variables.

2.1.1 Climate

Climate is identified as a fundamental determinant of the nature of terrestrial ecosystems by many studies including Radford (1981), Bailey (1988), Grace (1989), and Prentice et al. (1992). The most basic climatic gradient in Ontario is latitudinal (north-south); this latitudinal gradient is correlated with vegetation distributions (e.g., Carleton 1979, Cox and Moore 1993) productivity (Leith 1975) and diversity (Cox and Moore 1993, Perera et al. 1994a). The effect of the earth's geometry on incoming solar radiation and related temperature patterns is the primary driver of this gradient (Gates 1980). This gradient is modified by moisture gradients, continentality, topography, and other factors outlined below.

2.1.1.1 Solar Radiation

The amount of radiation available to ecosystems is a function of the earth's orbital geometry (and hence latitude, longitude, time of year, and time of day) and the amount of cloud obstructing direct radiation (Gates 1980). Radiation reception is further influenced by slope and aspect and by the properties of local land cover. Although heat energy (discussed later) is a crucial biological requirement of ecosystems, the light itself plays a crucial role in controlling photosynthesis. A number of studies identify solar radiation as a more critical variable than temperature in controlling ecosystems, showing increases in total stand biomass and net annual production to be correlated with net annual radiation (Bonan and Shugart 1989, Davis and Goetz 1990). Bonan and Shugart (1989) point out that other theories relating production to frontal activities are actually a measure of how frontal systems affect local energy budget.

Spatial radiation data for Ontario is limited. Weather stations provide temperature and precipitation data, but direct radiation measures are available for only a few sites. For the purposes of this study, the temperature variables outlined in the next section combined with terrain complexity (Sections 2.1.3, 2.2.2) provide the only means of modelling the influence of radiation on ecosystem processes.

2.1.1.2 Temperature

Most of the studies investigated include some representation of heat energy as a crucial biological variable. These usually involve measures of annual mean temperatures or heat duration such as growing degree days. The latter is found in many growth models. Such models

incorporate summer warmth and winter cold, usually by calculating an annual sum of temperatures exceeding a threshold value such as 5°C (Prentice et al. 1992). Some studies list extremes in temperatures as important limiting variables. Waring and Schlesinger (1985) propose that because trees can adapt their optimal ranges to different mean conditions, the frequency and duration of extremes may be more important than mean annual temperatures. Winter cold is seen as a limiting factor in northern situations (Neilson et al. 1992b, Junttila and Nilsen 1993), but summer temperature is commonly considered the primary determinant of boreal forest treelines. These lines often correspond to a threshold isotherm of 10°C for the warmest month (Grace 1989, Grace and James 1993). Estimates of the point of zero tree growth range from 4.4°C noted in Botkin (1993) to 8.8°C presented by Grace and James (1993). The optimum temperatures for photosynthesis occur between 15-25°C for temperate trees (Waring and Schlesinger 1985).

Studies of planetary warming under increased CO_2 scenarios provide additional information about temperature patterns. Prentice et al. (1992) suggest that higher latitudes have the most sensitive thermal ranges and will be affected more by small temperature increases than more equatorial sites. Temperature also plays an important role in controlling decomposition rates (Waring and Schlesinger 1985, Prentice et al. 1992). The latter suggest that this climatic effect on decomposition may be more important than direct measures of nitrogen.

Related to temperature and energy flows is the length of the frost free period and the spatial extent of permafrost. The number of frost free days is identified as an important factor by Radford (1981).

Temperature surfaces were obtained from the Ontario Climate Model (OCM) through the Ontario Ministry of Natural Resources (OMNR) Genetic Heritage Program. The model incorporates a number of interpolation methods developed specifically for use with climate data. The model uses latitude, longitude, elevation and mean monthly estimates of precipitation and temperature to derive a series of bioclimatic variables on a grid basis. This process is detailed in Graham (1995). Table 1 provides an overview of the temperature variables included in the analysis.

2.1.1.3 Moisture

Like temperature, precipitation is important in several different contexts. Precipitation is identified as a key element in photosynthesis (Waring and Schlesinger 1985) and like temperature, it is correlated on a large scale with vegetation and productivity (Leith 1975). Often the results of precipitation events are more important than water reception at the surface. According to Neilson et al. (1992a), biomes are delineated more effectively by analyzing runoff regimes than they are using moisture input.

The seasonality of precipitation is also critical. Neilson et al. (1992a) hypothesize that winter precipitation is crucial because few areas receive enough growing season precipitation to overcome the seasonal water deficit. This suggests storage in deep soil reservoirs, a hypothesis also supported by Neilson (1992a) in their work correlating woody vegetation to winter precipitation. The relationship of moisture to soil is the most important facet of moisture as a controlling variable.

Other moisture factors include humidity and fog. Humidity limits the evaporative gradient between the atmosphere and vegetation (Waring and Schlesinger 1985) and fog provides a local source of moisture in large valley systems and coastal/marine situations.

Similar to temperature, precipitation surfaces were derived from the OCM (Table 1). January, July, and annual mean precipitation surfaces were incorporated. Relative humidity and spatial fog data were not consistently available from these climate stations. This should not be significant since their effects will be localized and probably not relevant at the regional level.

2.1.1.4 Wind

The effects of wind as an ecosystem controlling agent are most apparent in northern situations, particularly at the treeline. Windborne particulate matter and ice induce water stress by damaging the epidermis (Grace and James 1993). Wind also causes physical damage through breakage, further impeding growth. In summer, net photosynthesis is reduced due to cooling caused by wind (Robertson 1993). At the present time, a consistent source of wind data for Ontario was not available to generate a spatial variable for this study.

2.1.2 Geology and Landform

Geology and landform act as important environmental controls on a number of levels. A distinction must be made between major categories of geology. Bedrock geology refers to the parent rock material beneath the mineral soil and surface deposits, whereas surficial geology (dominated by processes of the Quaternary period in Ontario) refers to surface deposits and resulting landforms.

2.1.2.1 Bedrock Geology

Bedrock geology can be important at different spatial scales. At the very broadest level in

Table 1. *Summary of variable surfaces included in the analyses.*

Variable	Source	Abbreviated name
Mean annual min. temperature	OCM[1]	Annmin
Mean annual max. temperature	OCM[1]	Annmax
Mean monthly min. temperature-Jan.	OCM[1]	Minjan
Mean monthly max. temperature-Jul.	OCM[1]	Maxjuly J
Mean monthly temperature - Jan.	OCM[1]	antemp
Mean monthly temperature - Jul.	OCM[1]	Julytemp
Mean annual temperature	OCM[1]	Anntemp
Growing season length	OCM[1]	Growlen
Annual growing degree days > 5°C	OCM[1]	anndd5
Mean annual precipitation	OCM[1]	Annpm
Mean monthly precipitation - Jan.	OCM[1]	Janpm
Mean monthly precipitation - Jul.	OCM[1]	Julypm
Elevation	Mackey et al. 1994	km1dem
Elevation Complexity	Baldwin 1997	Dembound
NDVI	Band 1994	Psnraw
Geology mean patch size	Baldwin 1997[2]	ge_mps
Geology edge density	Baldwin 1997[2]	ge_ed
Geology diversity	Baldwin 1997[2]	ge_sim
Geology contagion	Baldwin 1997[2]	ge_con
Landcover mean patch size	Baldwin 1997[3]	vg_mps
Landcover edge density	Baldwin 1997[3]	vg_ed
Landcover diversity	Baldwin 1997[3]	vg_sim
Landcover contagion	Baldwin 1997[3]	vg_con

[1]Derived from the Ontario Climate model. [2]Derived using classified LANDSAT landcover (Spectranalysis Inc. 1992, 1993; Perera et al. in prep.). [3]Derived using surficial geology database developed by Perera et al. (1996).

Ontario, ecological changes are evident between shield (igneous and metamorphic) and non-shield (sedimentary) systems due to the erosive and depositional characteristics of each. At a lower level, bedrock geology influences weathering rates, soil composition, and ground and surface water chemistry (Radford 1981).

Bedrock is a major pool for soil nutrients. Weathering of rock material typically makes up 80 to 100% of the Ca, Mg, K and P available for use by plants (Waring and Schlesinger 1985). This effect was shown to be important to vegetation response by Davis and Goetz (1990) who found bedrock associations were the key defining variable in their vegetation distribution study.

At the time of this study, a consistent digital bedrock geology layer was not available. A recent series of maps published by the Ontario Geologic Survey (Thurston et al. 1991) may provide a digital source for future study.

2.1.2.2 Surficial Geology

In Ontario, surficial units are categorized by origin, usually glacial, and further subdivided based on recent erosional and depositional forms caused by weathering and fluvial action. These more detailed divisions are reflected in slope and aspect attributes influencing smaller scale landforms. Landform is seen as a key ecosystem defining variable in a number of studies, some of which place landform ahead of climatic factors in relative importance. Rowe (1988) contends that landform controls climate at all levels, regulating incoming radiation and precipitation. He cites repetitive slope/vegetation-relationship sequences as proof of this phenomenon. Graham et al. (1990) suggest that movement of materials and organisms is regulated by the barriers, corridors, and gravitational gradients introduced by landforms.

A province-wide surficial geology digital database has recently been developed by Perera et al. (1996). This thematic layer is a compilation of various sources, including Chapman and Putnam's (1984) work in southern Ontario and Boissonneau (1965a, 1965b) and Zoltai's (1963, 1965a, 1965b) work in northern Ontario. Section 2.2.4 outlines procedures developed to create a series of quantitative variables from this discretely classified dataset.

2.1.3 Terrain

The effect of elevation on ecosystems is well defined in the literature in terms of altitudinal gradients, lapse rates, and orographic rainfall effects on vegetation and other ecosystem processes (Hills 1959, Gates 1980, Bailey 1988, Botkin 1993, Cox and Moore 1993). This is shown in many treeline studies, which often discuss altitudinal and latitudinal treelines simultaneously (Grace 1989, Grace and James 1993).

Two derivatives of elevation, slope and aspect, play a more integral role in ecosystem function than simple elevation. Their effect, however, is usually associated with finer spatial levels. As mentioned earlier, slope and aspect are critical in controlling the solar radiation received by an area. They can create warmer than normal areas on south slopes, and colder than normal areas on north slopes.

Slope and aspect affect processes at finer spatial scales than the regional-unit level. The Ontario digital elevation model (Mackey et al. 1994) is used in this study for terrain information. A surface was developed to quantify terrain complexity and to identify areas of complex terrain that may have a stronger regional effect on ecological processes. The derivation of this surface is outlined in Section 2.2.2.

2.1.4 Soils

The importance of soil processes falls into 2 major categories: soil moisture regimes and soil nutrient regimes. Both of these categories operate at relatively small spatial scales (Bailey 1988).

2.1.4.1 Soil moisture

Soil moisture is dependant on both the climatic inputs as well as the groundwater conditions and

physical properties of the soil, particularly texture. The balance maintained by these factors is characterized by water deficit measures (Pojar et al. 1987, Prentice et al. 1992). As mentioned earlier, deficit situations may be counteracted by deep storage of winter precipitation (Neilson et al. 1992b).

The effect of soil moisture combined with temperature on soil microorganisms drives decomposition rates and the production of litter to be reincorporated (Zak et al. 1986). A wetness index, in combination with slope, accounted for almost 50% of variability in A horizon thickness, pH, organic matter content, extractable P, and silt and sand contents in studies by Moore et al. (1993).

2.1.4.2 Soil Macronutrients

Macronutrients are elements used in large amounts by all life forms. The response curves of plants to these elements are usually exponential (Botkin 1993). Pojar et al. (1987) state that soil nutrient analyses are made very difficult due to complex interactions of topography, climate, soil, and organisms. This observation seems to be reflected in the lack of quantification of any of these parameters over broad spatial scales.

Several studies outlined the importance of N, C, S, and P, however these roles were primarily associated with smaller spatial scale processes of actual vegetation function and cycling.

Provincial-scale soils data are very limited. Broad regimes are defined in the Ontario Land Inventory (OLI), but unfortunately, these data do not cover the entire province. Similar to slope and aspect, changes in soil parameters are generally accepted to be less important at the regional level. The parent material patterns obtained from the surficial geology dataset outlined earlier are probably more relevant at the regional level.

2.1.5 Landcover

One of the limitations of the existing systems is that their development was based heavily on existing vegetation. To examine their robustness for delineating ecosystems, more recent vegetation data should be quantified. Using functional types rather than detailed species information will result in a more robust picture of the processes involved, smoothing out successional change over time. This approach has been effective even for more detailed growth modelling (Prentice et al. 1992).

Although the relationship of vegetation to climate is usually examined with vegetation as a response to climate, a number of studies document effects in the opposite direction. Bonan et al. (1992) indicate that surface climate may be driven by vegetation cover due to changes in albedo (light energy reflectance). This is supported quantitatively by de Bruin and Jacobs (1989). They found that net solar radiation over forests can be 20% higher in summer and 10% higher in winter than over open land, due to the lower albedo of the forest.

Vegetation also plays a role in landscape-level nitrogen cycling. The availability of litter to form detritus, in combination with heat and moisture conditions, determines a large portion of the available nitrogen. Again, a very broad vegetation classification, which provides a crude indication of litter potential, would be useful.

Classified LANDSAT Thematic Mapper data have been compiled for the province and are available from the Ontario Centre for Remote Sensing (OCRS). Like the surficial geology layer, these data were compiled from a number of base sources and classified to a consistent provincial scheme. This compilation was developed jointly by the Forest Landscape Ecology Program (FLEP) at the Ontario Forest Research Institute, OCRS, and Spectranalysis Inc. (1992, 1993). The classification used for this study was developed for a compilation of Provincial Park data (Perera et al. in prep). Similar to the geology dataset, a series of quantitative variables have been derived to characterize the discreet landcover data. Details of these variables are presented in Section 2.2.4.

In addition to these vegetation structure variables, a surface of normalized difference vegetation index (NDVI) derived from Advanced Very High Resolution Radiometer (AVHRR) data was developed by Band (1994). This surface shows the varying effect of chlorophyll content of the surface, providing a measure of "greenness". An annual aggregated surface was used in this study to represent a broad measure of landcover conditions.

2.2 Spatial Dataset Development

The variables relevant to basic ecosystem composition and function defined in Section 2.1 were obtained from various sources and are at different spatial resolutions. This section outlines how we generated a consistent spatial database of these variables for analysis.

2.2.1 Climate Variables

The climate variables were extracted from the Ontario Climate Model (OCM) outlined in detail by Graham (1995). Each surface was registered and maintained as a 1-km resolution, quadtree compressed raster using SPANS GIS software (TYDAC Technologies 1994). These rasters were resampled to 10-km resolution for the core analyses outlined later.

2.2.2 Terrain Variables

The elevation surface was obtained from Mackey et al. (1994) and registered at 1-km resolution using SPANS. A surface was derived to quantify terrain complexity using a boundary modelling function in SPANS (TYDAC Technologies 1994). This algorithm returns the number of cell boundaries that have different adjacent values within a neighbourhood surrounding each cell (Figure 1). Only non-zero values in the neighbourhood are used.

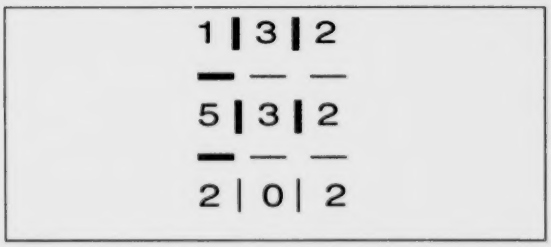


Figure 1. *Boundary function calculation. This 3 x 3 neighbourhood returns a value of 6 (thick bars and dashes indicate interfaces with different adjacent, non-zero values).*

The raw elevation surface was pre-classified into 25-m intervals to eliminate excessive noise. The boundary function was applied to this elevation surface using a 5 x 5 neighbourhood to delineate complex versus gentle terrain. Three-dimensional representations of the elevation model were examined to confirm the correlation of this surface to complex terrain areas.

2.2.3 Landcover

An annual aggregated NDVI surface from Band (1994) was used to represent a broad measure of landcover conditions. This surface was obtained at a resolution of 1 km and then imported and registered in the SPANS project study area.

2.2.4 Landcover and Geology Spatial Structure Variables

The classifications of LANDSAT landcover and surficial geology are nominal, that is, there is no inherent order to their values (Table 2). For example, there is no measurable gradient between ground moraine and eskers. In this form, these layers were not appropriate for the statistical tests used to analyse the systems. A series of spatial indices was developed based on these layers to provide variables that define the structure of these attributes. A specialized program was written to combine the spatial data manipulation functions of SPANS with Fragstats. Fragstats is an application developed to calculate a series of spatial metrics for landscape ecological applications (McGarigal and Marks 1993).

Table 2. *Nominal classifications of LANDSAT landcover and surficial geology.*

Landcover[1]	Geology[2]
Water	Bedrock
Coastal Mud Flats	Ground Moraine
Coastal Marshes	End Moraine
Inland Marshes	Esker
Hardwood Swamp	Outwash Deposit
Miscellaneous Wetlands	Lacustrine Deposit
Fen	Beach and Aeolian Deposit
Open Bog	Organic Deposit
Treed Bog	Limestone and Shale Plains
Tundra Heath	Escarpment
Dense Deciduous Forest	
Dense Coniferous Forest	[1]As classified by Perera et al. (in prep.)
Mixed Forest Mainly Deciduous	[2]As developed by Perera et al. (1996)
Mixed Forest Mainly Conifer	
Sparse Forest Cuts and Burns	
Urban / Built-up Areas	
Agriculture	
Pasture and Abandoned Lands	

This program was used to calculate local measures of the spatial characteristics of the landcover and geology for 10 km x 10 km "landscapes" centred on each of the points used to sample the other variables (outlined later). The landcover and surficial geology data were examined at 125-m resolution within each landscape. Four of the many spatial metrics calculated by Fragstats were chosen to quantify the landcover and geology layers: mean patch size, edge density, Simpson's diversity index and a contagion index. The detailed formulae for these indices are available in McGarigal and Marks (1993).

Mean patch size reports the average size of clusters of the individual classes in the dataset. Edge density quantifies the amount of perimeter of the various class boundaries divided by the total landscape area. Both of these indices quantify the spatial complexity of the landcover or geology at each location. These measures for vegetation provide surrogate indications of the disturbance regimes and succession patterns in terms of the patch sizes on the landscape.

Simpson's diversity index measures heterogeneity based on richness (the number of different classes) and evenness (how the area is divided among these classes). This index reflects the compositional structure of the vegetation and geology types at each location.

The contagion index quantifies the spatial pattern of class distribution, ranging between clumped and dispersed patterns. This is also useful in assessing the landcover pattern in terms of disturbance characteristics and succession patterns. This index, used with the geology dataset, measures the spatial complexity of geology types, which influences soil development patterns.

2.2.5 Ecoregionalization Layers

The spatial depictions of the ecoregionalization systems were obtained from various sources. The

Hills system was digitized by FLEP from a 1:1 584 000 scale hardcopy map (Figure 2a). This layer was maintained at 125-m resolution to generate smooth lines for the buffering processes discussed later.

The TEO system was digitized from a 1: 1 500 000 scale map (Wickware and Rubec 1989) by the Forest Resources Inventory section of OMNR. Originally in Arc Info format, the data were converted to SPANS and maintained at 125-m resolution (Figure 2b).

The RTEO framework (Figure 2c) was obtained directly in digital format from Agriculture Canada's office in Guelph, Ontario. These data were also converted from Arc Info format to SPANS and maintained at 125-m resolution.

2.3 Multivariate Dataset Preparation

The values of each variable and a region label for each system were added to points generated at 1-km intervals for the boundary gradient analyses and 10-km intervals for the region core comparisons outlined later. The variable surfaces were resampled to 10-km resolution for the region core comparisons. The points were exported to create a multivariate dataset for SAS (SAS Institute 1993). All of the variables were standardized to have a mean of 0 and a standard deviation of 1 to eliminate differences in measurement scales among variables.

2.4 Compositional Statistics

Simple univariate statistics were generated using all of the variables to characterize each regional unit. These values were generated as a reference for users of the systems and a quantitative basis for comparing the systems.

a) Hills Site Regions (Hills 1959)
b) Terrestrial Ecoregions of Ontario (Wickware and Rubec 1989)
c) Revised Terrestrial Ecoregions of Ontario (Ecological Stratification Working Group 1995)

2.5 Region Core Analyses

Each system was examined for its robustness in partitioning the geoclimatic variables. Since limited spatial precision of regional boundaries is inherent in the construction of each of these systems, comparisons among regions were confined to "core" areas.

2.5.1 Core Area Definition

Core areas were modelled by imposing a buffer inward from the boundaries. A buffer distance of 40 km was selected to define robust region cores that retained viable sampling size. The region lines were extended past the provincial boundaries to eliminate this arbitrary effect. Ecologically, this administrative delineation has no true meaning except in cases where the boundary is defined by significant natural features such as the Great Lakes or Hudson's Bay. Figure 3 illustrates this procedure using the Hills system as an example.

2.5.2 Variance Component Analysis

An effective classification should show greater variance between its regions than within its regions. The within-region to between-region variance was examined using a breakdown of the variance for each variable across the units of each system and the SAS Varcomp procedure.

2.5.3 Multivariate Distance

The internal structure of each system was examined by calculating the multivariate distance (Mahalanobis distance) between each pair of regions (SAS Institute 1993). This indicates the difference among regions based on all variables simultaneously.

The distances between each of the regions were calculated and sorted to examine the relationships between multivariate distance and spatial proximity, and to illustrate the relative strength of the boundaries between units. Choropleth maps were generated to show the total of all multivariate distances for each region as well as the pairwise values between each individual region and all of the other regions within a system.

a) Hills Site Regions (Hills 1959).

b) Terrestrial Ecoregions of Ontario (Wickware and Rubec 1989).

c) Revised Terrestrial Ecoregions of Ontario (Ecological Stratification Working Group 1995).

Figure 2. *Existing ecoregionalization systems for Ontario.*

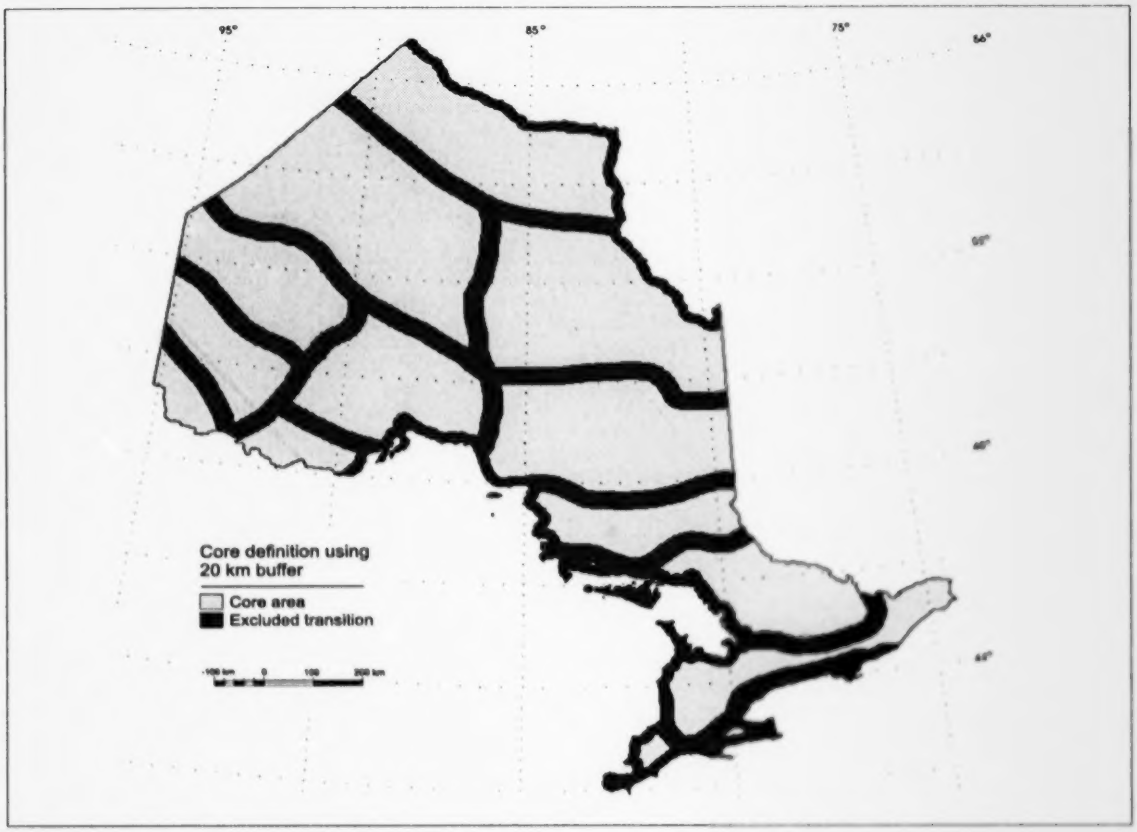


Figure 3. *Core area preparation for the Hills system.*

2.5.4 Surficial Geology Similarity

The regional core units were compared in terms of their surficial geology compositional similarity using the Morisita-Horn index of similarity (Turner and Gardner 1991). Choropleth maps were generated similar to the multivariate distance comparisons outlined in Section 2.5.3.

2.5.5 Principal Components Analysis

Principal Components Analysis (PCA) is a multivariate technique used for summarizing and detecting linear relationships among several variables. Typically it is used to reduce the number of variables needed in an analysis by creating a lesser number of principal components. These components are linear combinations of the variables with coefficients or loadings showing correlations between the variables and each component. The first component contains the most variance, followed by components containing less and less variance. The loadings of the variables for each component indicate positive or negative correlations with the first few components that explain most of the variance.

PCA was used primarily to examine the internal structure of each system. PCA was conducted for each regional unit, using all variables. The loadings of each variable for the first few principal components were sorted for each regional unit to identify key variables related to the region's structure. Maps were created for each system, showing a bar chart in each region with the eight largest positive loadings colour-coded by the relevant variable. These maps were generated for the first 3 principal components, which together typically explain more than 70% of the variance in each region.

2.6 Region Boundary Analyses

In the region core analyses outlined above, the transition zone surrounding the region boundaries was eliminated to compare and contrast regions. In this set of analyses, this transition was examined in detail to identify the existence and relative strength of trends in variables across each interface.

2.6.1 Database Preparation

A gradient was generated across each regional interface by creating 10-km wide bands, 50 km in each direction from the boundary (Figure 4). Points were generated at 1-km intervals within the bands and the region identifiers, buffer distance, and geoclimatic variable values were attached to the points. The spatial metric variables for vegetation and geology structure generated for the core analyses were not included in the dataset because they relate to the 100 km^2 "landscapes" and are too coarse for this analysis. Some interfaces were not examined, particularly northern units where climate interpolation is weak due to low climate station density (Figure 5). These omitted interfaces are shown in Table 3.

2.6.2 Means, Multivariate Distance, and Geologic Similarity Comparisons

The means for all variables were calculated for each band across each regional interface. The multivariate distance (Mahalanobis distance) and the geologic similarity (Morisita-Horn index) were calculated between adjacent band pairs. These values were plotted against an x-axis of the 10-km bands, centred on the regional boundary. The presence and strength of trends across the region interface were assessed.

2.6.3 Trend Comparison Statistics

Indices were developed to quantify the trends across the region interfaces using the slopes at different points over the gradient. The gradient was broken into 3 sections: a "core" area (30 km on each side of the boundary) and two "tail" areas (remaining 20 km in each region). Line slopes were calculated for each variable between successive bands. Each section's slopes were compared as proportions of the overall trend to standardize for the different variable scales.

Table 3. *Interfaces omitted from the regional boundary analyses.*

Hills	TEO	RTEO
1E / 2W	1/2	89/90
1E / 2E	2/3	89/95
2E / 2W	2/5	95/216
	3/4	98/133
	3/5	132/133
	3/6	133/134
	3/7	215/216
	10/12	216/217

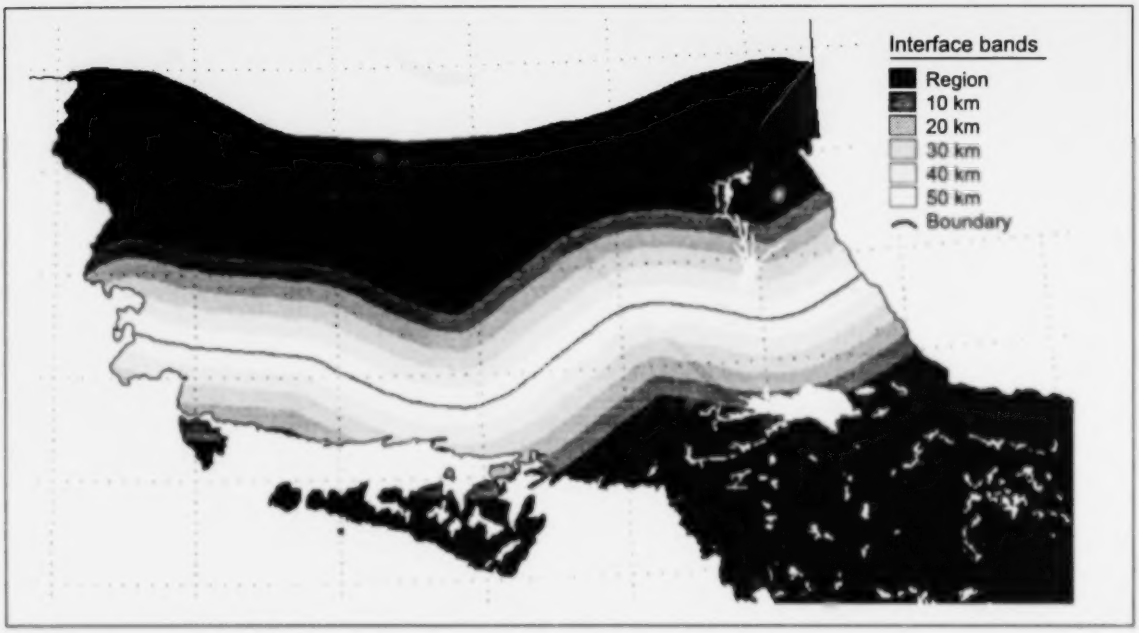


Figure 4. *Boundary gradient preparation (Hills system 4E/5E interface).*

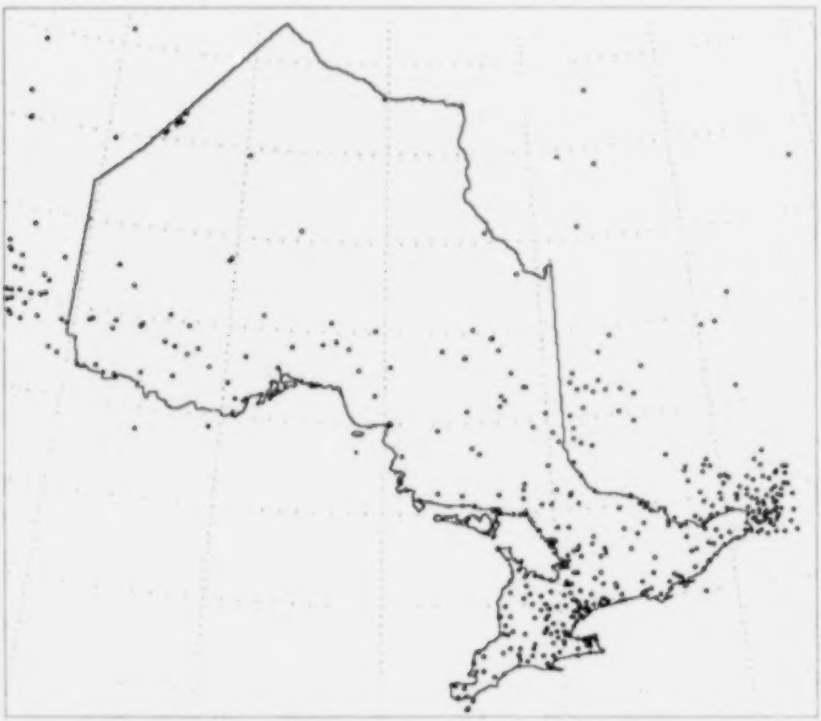
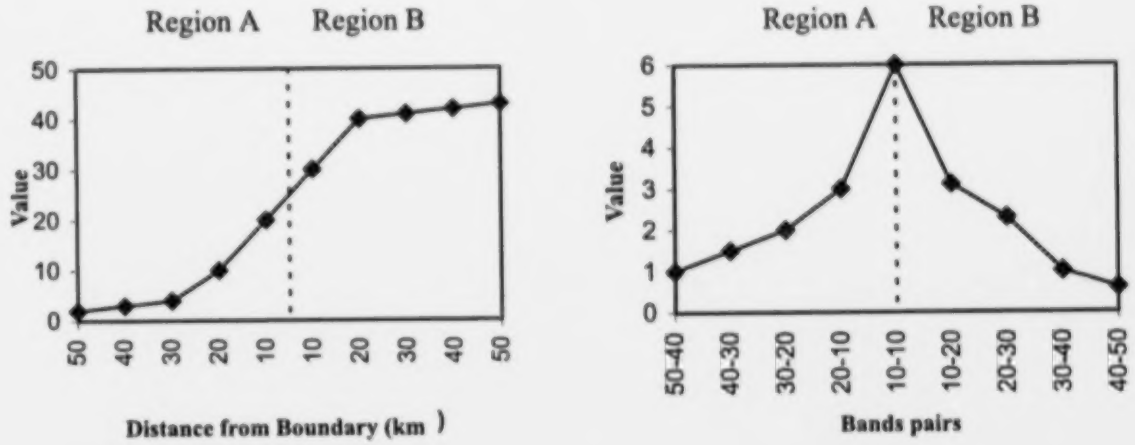


Figure 5. *Climate stations used to develop climate surfaces (Atmospheric Environment Service 1995).*

This relationship was calculated and interpreted differently depending on the type of analysis. For example, comparing means, a strong boundary trend is illustrated by a gradual slope in the first region tail followed by a sharp increase or decrease across the boundary and then more gentle slopes away from the boundary into the second region. In contrast, strong multivariate distance trends are shown by a rapid increase in dissimilarity approaching the boundary from each region. Examples of strong trends for different comparison types are shown in Figure 6. Figure 6a shows a strong trend for the mean comparison (index value is 0.9024 calculated as the sum of slopes in the core area as a proportion of all slopes). Figure 6b illustrates a strong multivariate distance comparison trend (index = 0.7404 calculated as the sum of the absolute values of slopes in the core area as a proportion of all slopes). A strong trend for geologic similarity would be a vertical mirror image of Figure 6b.

The shapes of all curves were examined in conjunction with the index values to create a ranking scheme for the variables within each region. A ranking of strong, medium, weak, or no trend (scored 3, 2, 1, and 0, respectively) was determined for each variable over each interface, using threshold values of the index in combination with line shape. These scores were tabulated to summarize the trends across each interface, for each system. Total scores, standardized by the number of interfaces in each system, were calculated to compare systems. Summary maps were prepared, with boundary line widths proportional to the strength of the boundary, based on the scores. The top 5 variables for each interface were graphed to illustrate which variables display the strongest trends.



a) Mean comparison

b) Multivariate distance comparison

Figure 6. *Examples of strong trend patterns for means comparison and multivariate distance comparison methods.*

CHAPTER 3

Results and Discussion

This chapter presents the major results of this study. In addition to the charts and maps presented here, the reader may find it useful to refer the appendices, which contain much of the basic data used as a reference for studying individual regions of the systems.

3.1 Composition and Summary Statistics

Univariate statistics were calculated for each variable within each region to provide a basic characterization of each unit. These results will not be examined in detail but are listed in Appendix I to serve as a reference for this study and for anyone using these systems in future studies.

The final sample sizes for the 10-km dataset for each system (Table 4) show that a bias was introduced, favouring larger regions over smaller, thinner regions, as a result of the core delineation process (Section 2.5.1). Although a consistent buffer width was used, this buffer removed a larger proportion of the smaller, narrower units and eliminated one small region (133 in RTEO system). This is important when examining the trends among core units.

3.2 Regional Core Analyses

3.2.1 Variance Component Analysis

Appendix II summarizes the variance components (within region or between region) for each variable by system. The results for the 3 systems are very similar, each showing considerably less within-region variance compared to the between-region components for almost every climate variable. All systems showed particularly strong partitioning of the various temperature measures with only slightly lower partitioning strength among precipitation variables.

Neither landcover and surficial geology structure variables nor terrain complexity were well partitioned by the systems; a number of these measures display greater within- than

Table 4. *Frequency of of 10-km data samples by system and region.*

Hills		TEO		RTEO	
Region	Freq.	Region	Freq.	Region	Freq.
1	850	1	70	89	147
2	1244	2	649	90	767
3	1089	3	569	91	144
4	485	4	34	92	7
5	558	5	858	93	135
6	880	6	709	94	450
7	301	7	462	95	725
8	138	8	447	96	690
9	326	9	36	97	516
10	81	10	67	98	363
11	432	11	126	132	39
12	341	12	183	134	171
13	26	13	635	135	48
14	292			215	89
15	138			216	538
16	189			217	1002
17	18				

between-region variance. Only very minor differences were apparent among the systems.

The variance component results suggested that all of the systems partition geoclimatic variables well. This test however may be overstating this result. In Ontario, the variance of many of the climate variables is linear and almost uni-directional, either latitudinal (temperature) or longitudinal (precipitation). This makes drawing 10 or 20 regions that partition most of the variance of this multivariate dataset a fairly rudimentary exercise. This does not diminish the merits of the existing systems; the authors of these systems could do this better than anyone, with knowledge of the subtleties of the ecological composition of the landscape well beyond the data. This does, however, limit the usefulness of this type of analysis for quantifying systems in Ontario or other locations where the variance patterns are similar. The differentiation of regions is better illustrated by the multivariate distance and geologic similarity analyses.

3.2.2 Multivariate Distance Analysis

The multivariate distances were calculated among regional units as outlined in Section 2.5.3. Figure 7 shows the regions shaded proportional to the total of all pairwise distances between each region and all others in the system. In Appendix III, each region is examined individually, shading all other regions proportional to the pairwise distance from the focus region (shaded in white). The following sections outline the major trends evident for each system. Varying shading levels for these choropleth maps made labelling of region names difficult. It will be useful to refer to Figure 2 for the following sections to match the region names with the choropleth maps.

3.2.2.1 The Hills System

The high total multivariate distances in Regions 6E and 7E (Figure 7a) are the most notable pattern in the Hills system. They are distinct from the other regions and also from each other as shown by the moderately high multivariate distance between them (Appendix III). This most likely reflects the influence of climate variables, particularly temperature. These regions are spatially isolated from the other regions, with no counterparts at similar latitudes. In addition, sampling density for the climate variables is higher — there are many more stations in these southern regions — and the climate interpolations are much stronger (Figure 5).

Region 1E shows relatively high total distance values, but this region is not as strongly separated from its neighbours as the southern units. This may also be related to its spatial isolation in higher latitudes than the other regions. The westernmost regions (3S, 4S, and 5S) show low total multivariate distance values as well as low multivariate distances from their neighbours.

The patterns shown in Appendix III for most regions are consistent concentric increases in multivariate distance spatially from the focus region. This is in contrast to the patterns for geology similarity outlined later.

3.2.2.2 The TEO System

There are a number of similar patterns in the TEO system. The southern and northern units that have high total multivariate distance scores, namely regions 1, 2, 15, 16, and 17 (Figure 7b). Again, the southern regions are well defined from each other as well as from the rest of the regions. Region 9 also appears quite distinct from the other regions. This is probably influenced by the very low sample size for this region (see Table 4), which also affects the results for Region 17.

Like the Hills system, the westernmost regions of the TEO system are poorly differentiated from each other and from the other regions. The pattern of concentric increasing multivariate distance is also evident in this system. There are no examples of regions being more similar to spatially disjunct regions than nearby regions.

3.2.2.3 The RTEO system

In the RTEO system, high total multivariate scores are evident again in both the extreme northern (216, 217) and the extreme southern (132, 134, 135) regions (Figure 7c). Once again, the

a) Hills

b) TEO

c) RTEO

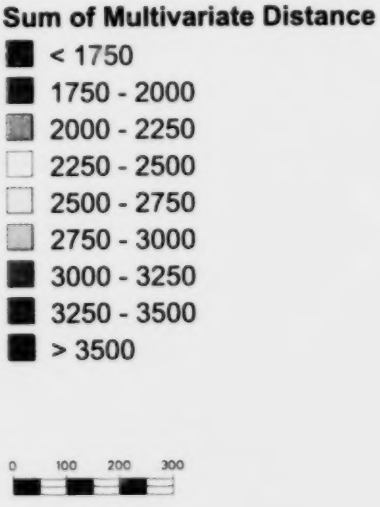


Figure 7. *Total multivariate distance by region for each ecoregionalization system.*

southern units are well separated from each other, while the northern regions are not (Appendix III). The westernmost units show the weakest differentiation, particularly Region 90. Similar sample size problems are found in this system, particularly for Region 92, which is so limited that it should be ignored in this analysis.

3.2.2.4 Summary of Multivariate Distance Analyses

The multivariate distance analyses showed a number of trends which are fairly similar among the systems. The southernmost and northernmost regions of each system showed the strongest differentiation from the rest of the system. The southern units were better differentiated among themselves than northern pairs. This most likely reflects their spatial isolation in lower latitudes, but could also be attributed in part to the shorter variance scales related to higher data sampling densities in the south for most variables.

This spatial isolation is also evident in the patterns of multivariate distance examined for each region individually. In almost all cases, the distance patterns followed a concentric pattern outward from each region. This suggests that the dataset was dominated by almost uni-directional north-south variances of temperature variables and east-west variance of precipitation variables.

Another common trend in these analyses was the weakness of definition between central regions, particularly in the west. This combined with the strong definition of northern and southern units, suggests that many of the variables in this dataset may be more useful in defining units at the spatial level above the region, such as eco-zones or eco-provinces.

3.2.3 Similarity of Surficial Geology

The similarity of surficial geology composition among units is summarized in Figure 8a-c. The regions are shaded proportional to the sum of the Morisita-Horn values (see Section 2.5.4.) between the region and all other pairwise combinations with other regions (Appendix IV). The similarity in geologic composition does not follow a linear or concentric pattern as in the multivariate distance analysis.

3.2.3.1 The Hills System

The most striking trend in the Hills system map (Figure 8a) is how regions 1E and 2E stand out as very dissimilar from the other regions. The individual plots for these regions in Appendix IV show however that they are similar to each other, suggesting they form one larger unit from a geologic standpoint. This trend is apparent in all 3 systems. Surficial geology may be more relevant at a broader spatial scale, forming eco-province units. Region 2W seems to be very weakly defined in terms of geologic structure. In contrast, Regions 3S and 7E are strongly defined from a surficial geology perspective. Most of the other regions show high total similarity values and high values compared to neighbouring regions, again suggesting that geology may be more relevant at a broader spatial scale. One expected trend that does not appear, is a distinct difference between the units bordering the southern Cambrian Shield boundary (5E and 6E).

3.2.3.2 The TEO System

Figure 8b shows a similar pattern to the Hills system. Regions 1, 2, and 5 have low total similarity values, suggesting that they are different from the other regions, and high similarities between each other (Appendix IV), suggesting that they comprise a larger geologic unit. Region 7 also stands out, with a relatively low total similarity value and low pairwise similarity values with many other regions. This trend is similar to the Hills system unit 3S. Once again the differentiation of the southern Cambrian Shield boundary is not apparent (Regions 14 and 16). The eastern shield boundary is defined by moderate similarity between Regions 15 and 16. Regions 10 and 13 show very weak differentiation except with the Hudson's Bay Lowland units. These regions are similar to many others throughout the province (Appendix IV) and have high total similarity values (Figure 8b).

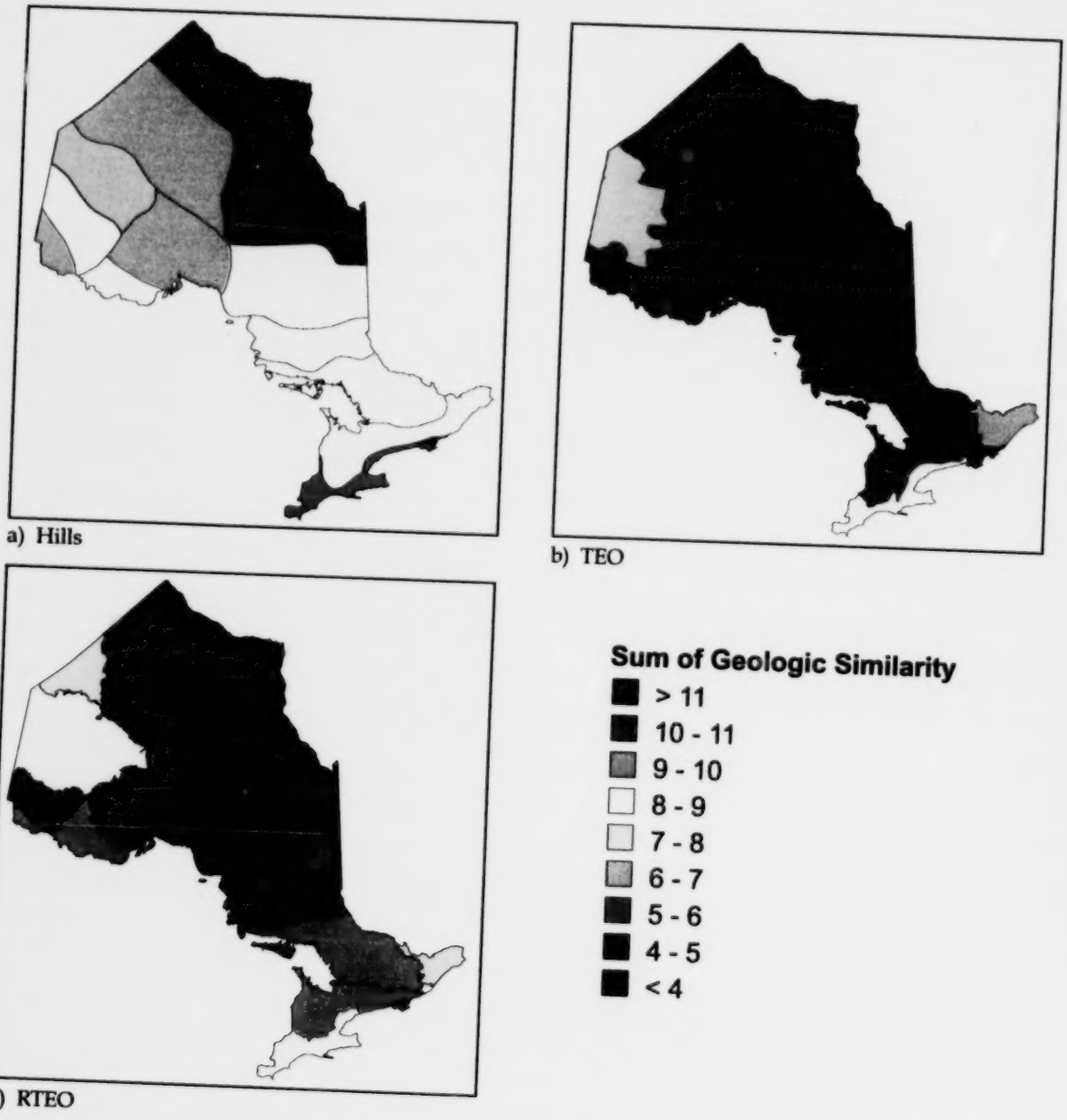


Figure 8. *Total geologic similarity by region for each ecoregionalization system.*

3.2.3.3 The RTEO System

The Hudson Bay Lowlands also stand out in the RTEO system. Regions 215, 216, and 217 have low total similarity values (Figure 8c) and high similarity values (Appendix IV). It is no coincidence that these region numbers are sequential. They are all part of the same eco-province in the next level above regions in the RTEO framework. Similar to the TEO system, the eastern Cambrian Shield boundary (Regions 98 and 132) is moderately strong and again, the southern boundary of the Shield is poorly defined (Regions 98 and 134). Most of the central units show high total similarities and high similarity values to neighbouring regions.

3.2.3.4 Summary of Surficial Geology Similarity Analyses

The regions approximating the Hudson Bay Lowland area in each system showed very low similarity values to other regions except among themselves. In addition, many of the central regions are not well differentiated. This suggests that the regions, as they are defined, may form complexes of geologic units that are subsequently broken down by other variables. This is consistent with Hills' construction methods, which started with landform units differentiated by climate and vegetation associations across these geologically based units.

3.2.4 Principal Components Analysis (PCA)

PCA was used to examine the correlation among the variables as well as the structure within each system. For each of the 3 core datasets, most of the variation (> 80 %) can be explained by the first 4 or 5 principal components. This suggests a large amount of correlation among variables, which supports using only the first few principal components in place of the entire dataset for subsequent analyses. However, the relationships among the variables and components are difficult to track when only principal component scores are used. In addition, explicit quantification using each of the variables is important for this study.

PCA was performed within each regional unit to examine the specific relationships of each variable to the variance structure of each region. Loadings for the first 3 principal components for each regional unit are presented in map form in Appendix V. The following sections outline general trends for each system.

3.2.4.1 The Hills System

The first principle component typically accounted for 50 to 60% of the variance in each region. This component appears to measure an overall climate effect with equal positive loadings for most of the temperature variables and to a lesser extent precipitation. This is true for almost every region except 6E, which shows strong positive loadings for vegetation structure and elevation.

Vegetation structure, geology structure, and precipitation appear to be important factors in many regions, illustrated by positive loadings in the second component. Regions 1E, 2E, 4S, and 5S show strong loadings for vegetation and geology structure variables. Precipitation is strongly loaded in 3S, 3W, 4W, and 5E. Region 6E shows almost even loadings for all temperature variables for this second component. July precipitation, NDVI, and vegetation structure have positive loadings in 7Es second component. Vegetation and geology structure are also prevalent in the positive loadings of the third component in most regions. Temperature variables show stronger positive loadings in regions 1E and 2W.

3.2.4.2 The TEO System

Similar to the Hills system, the first component in most regions shows almost even positive loadings for all of the temperature variables. Vegetation structure dominates the second component loadings especially for Regions 2 to 6 and 15. Geology structure shows strong loadings in Regions 1, 8, and 17 and precipitation variables dominate in Regions 7, 9, 12, and 14. The loadings in Region 16 are positive for elevation and 2 precipitation variables. Geology and

vegetation structure also show the highest loadings in the third component for most regions. Regions 15, 16, and 17 show strong positive loadings for precipitation in combination with geology structure. Region 10 shows positive loadings with a number of temperature variables that were not strongly associated with the first component for this region.

3.2.4.3 The RTEO System

In the RTEO system, the loadings are fairly even among a number of temperature variables for the first component of most regions. Growing season length and growing degree day variables are more prominent in these loadings for this system than the other 2. Noticeably absent from the loadings in the second component for most regions are the geology structure variables, showing positive values only in Regions 95, 216, and 217. Vegetation structure displays strong positive loadings for a number of regions (89, 95, 132, 135, and 217). Precipitation variables are loaded heavily in Regions 93, 98, and 215. Geology structure shows positive loadings for a number of regions in their third component. This is usually the case in combination with strong loadings for either vegetation structure variables (Regions 89, 90, 95, 215) or precipitation variables (Regions 98, 132, 134, 135, 216, 217).

3.2.4.4 Summary of PCA Analyses

The regional PCA analyses have been included primarily as a reference for detailed study of individual regional units. Some generalities were found in the cursory examination of the results presented above. In general, the first component for each region showed strong loadings for temperature and growing season variables. The second and third components most often reflected vegetation and geology structure variables. These trends are consistent with the geologic similarity results described above because the dominant factors defining most regions were climate and vegetation structure, with a lesser emphasis on the geologic factors for each region.

3.3 Regional Boundary Analyses

3.3.1 Mean, Multivariate Distance, and Geologic Similarity Comparisons

The means of all variables, in each band, across each interface, were plotted and the curves examined to quantify trends across each boundary. An index was developed to quantify the proportion and pattern of slopes across these boundary gradient plots (Section 2.6.3). The shapes of the curves were used in conjunction with the index to score each interface for the gradient effect for each variable.

Multivariate distances between sequential bands across each interface were plotted. Similar to the means comparison, the shapes of these curves were examined in conjunction with an index derived to quantify the slopes. This process was also carried out for Morisita-Horn similarity values for surficial geology. The ranking scheme detailed in Section 2.6.3 was used to summarize the results in table and map form. These results are presented in the following section.

Summary tables in Appendix VI provide rankings for the means, multivariate distance, and geologic similarity analyses. Variables in columns are highlighted to indicate scores and the strength of the trend. Variables in rows are highlighted based on the strength of the interface trend. Summary columns along the bottom include a count of the number of variables that showed trends of scoreable strength (Count); the total score for each interface (Score); and its rank within the system based on these scores (Rank). Summary columns across the right hand end of the table include: a count of the number of interfaces that showed trends of scoreable strength (Count); the proportion of the count to the total number of interfaces (CountP); the total score for the variable (Score): the average score for the variable (ScoreA); and the rank of the variable within this system (Rank). The CountP and ScoreA fields provide useful values for comparing between systems. Also provided is the average score for all interfaces in the system.

In Figures 9 to 11, region interfaces are drawn with line thicknesses proportional to their final scores. Variables with the top 5 raw trend index scores are shown in bar charts for each region. Although the scoring and ranking scheme included the mean, multivariate distance, and Morisita-Horn similarity analyses, the raw trend index values for these analyses are not directly comparable. Symbols have been used to depict interfaces showing strong and moderate multivariate distance and geologic similarity trends to display this information with each interface graph. Individual interfaces will not be presented in detail, however, overall trends and certain specific interface cases will be discussed in the following sections.

3.3.1.1 The Hills System

The Hills system showed the strongest trends in surficial geology, followed by elevation, and growing degree days and temperature variables. This is not surprising because Hills started with landform as the basic framework and subdivided by vegetation/climate relationships within these landform units. What is surprising is that the poorest trends are shown for the NDVI surface. This might suggest that the vegetation association and succession subdivisions of the landform units have changed over time. On the other hand, the vegetation associations defined by Hills may have parallelled more stable climatic gradients.

The strongest interface score in this system was achieved by the 4S/5S boundary. This is interesting because in the revisions to Hills system proposed by Burger (1993), 5S was amalgamated into Region 4S based on forest composition criteria. Particularly strong interfaces are also present between Regions 4E and 5E and between 6E and 7E.

The 3S/3W, 4S/4W, and 4S/3W interfaces all show strong relationships with precipitation variables. This is not surprising as an west to east moisture gradient is evident in a number of these variables, however, this relationship is lost in a number of the comparable interfaces in the other 2 systems.

3.3.1.2 The TEO System

The TEO system had the lowest average interface score. Its strongest interface trends were shown in mean January temperature, minimum January temperature, and growing season length. The weakest trends were found in NDVI, elevation complexity, and maximum July temperature. The weak relationship with NDVI suggests that the use of LANDSAT data was focused primarily on geologic features rather than vegetation patterns. It is unlikely that significant changes have occurred in major landcover boundaries (except large fires and cuts) since this system was developed in 1989.

The highest ranked interfaces in this system were 13/14, 14/16, and 16/17. This coincides with high climate sampling density outlined earlier, however, the NDVI variable is not subject to this bias and is prominent in 2 of the 3 interfaces.

The moisture gradient in the west is not reflected to the same degree in this system as in the Hills system. Interface 7/10 in particular has no precipitation variables in its top 5 scores. A second step in this east/west gradient does appear farther east at the 6/8 interface. This boundary shows a strong trend based on July precipitation.

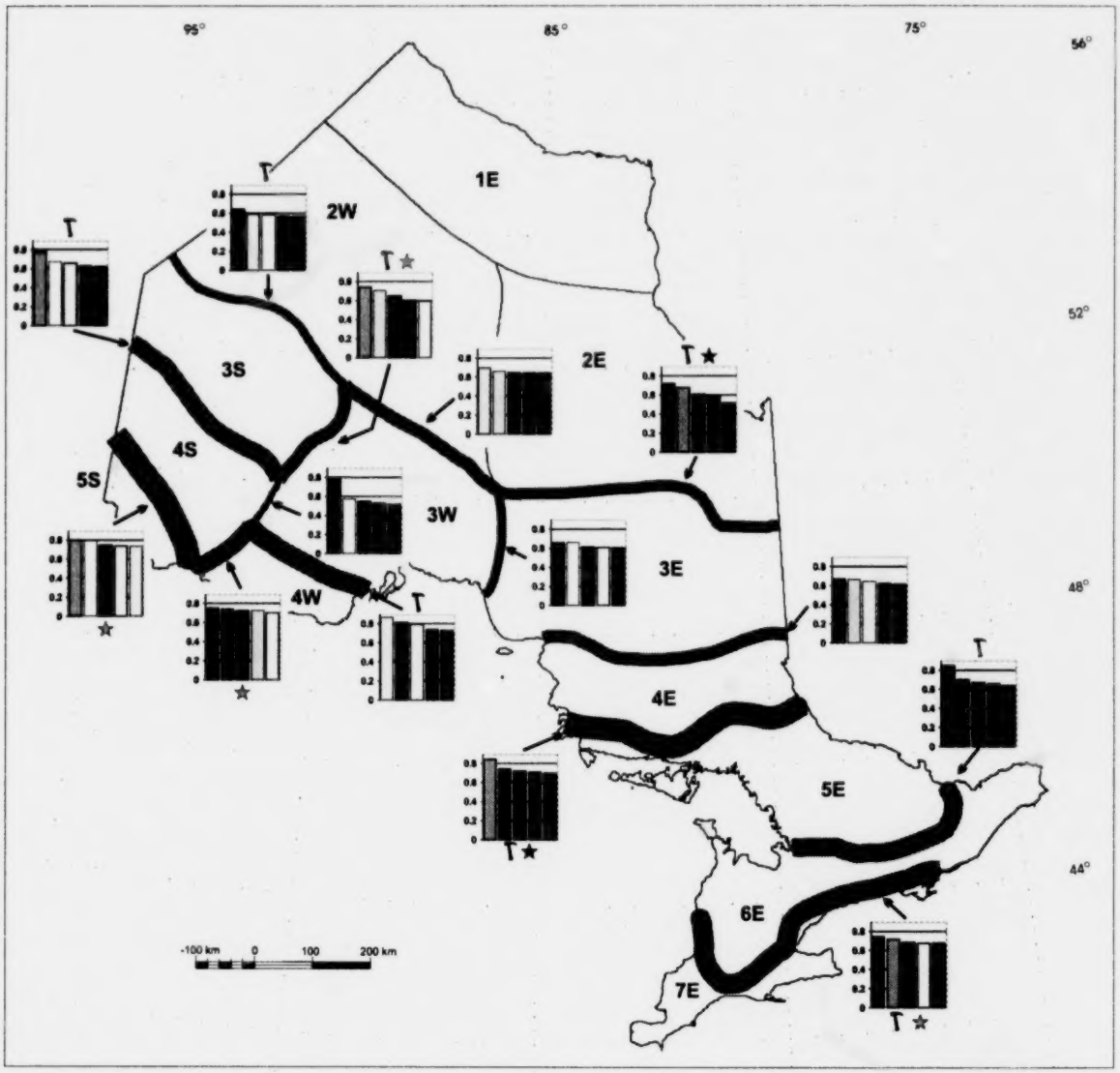
3.3.1.3 The RTEO System

The RTEO system had the highest average interface score. Strong variable scores were achieved in this system by annual minimum temperature, annual mean temperature, growing degree days, and mean January temperature. Low scores were found for January precipitation, elevation complexity, and annual precipitation.

One noticeable trend seen in the results for this system is the lack of precipitation variables in many of the interfaces, particularly for the north/south running boundaries in the west (91/93, 90/94, 93/94, and 94/96).

3.3.2. Summary of Boundary Analyses

Similar to the PCA analyses, the boundary analyses results are a reference for examining



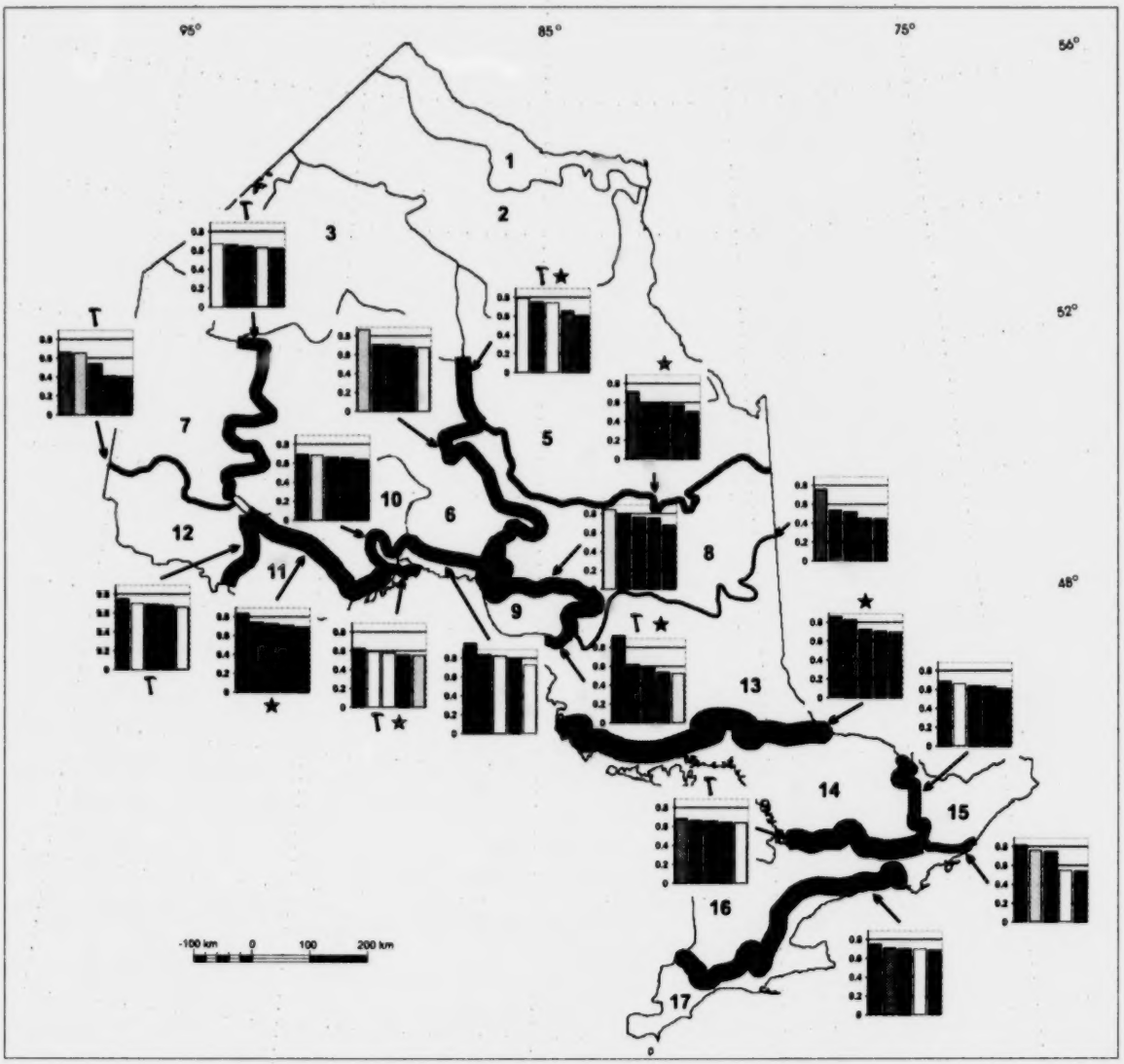
Legend

ANNPM
JANPM
JULYPM
ANNMAX
ANNMIN
MAXJULY
MINJAN
ANNTEMP
JANTEMP
JULYTEMP
ANNDD5
GROWLEN
DEMBOUND
KM1DEM
PSNRAW

Strong surficial geology trend
Moderate surficial geology trend
Strong multivariate distance trend
Moderate multivariate distance trend

Regional interface - thickness proportional to composite score of trend statistics for all variables

Figure 9. *Regional interface characteristics, Hills system. Bar charts indicate value of trend statistic for the top 5 variables.*



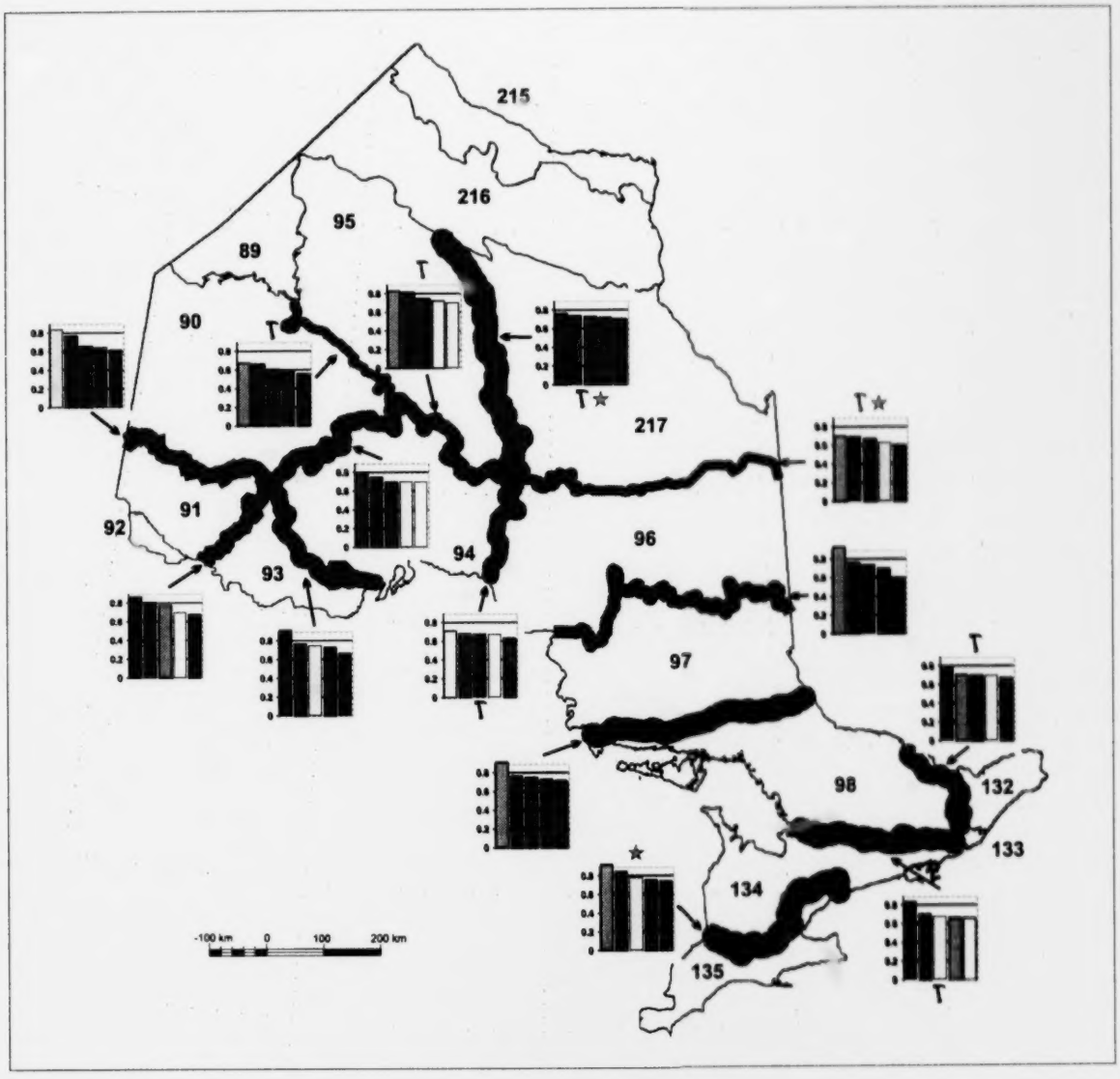
Legend

ANNPM
JANPM
JULYPM
ANNMAX
ANNMIN
MAXJULY
MINJAN
ANNTEMP
JANTEMP
JULYTEMP
ANNDD5
GROWLEN
DEMBOUND
KM1DEM
PSNRAW

Strong surficial geology trend
Moderate surficial geology trend
Strong multivariate distance trend
Moderate multivariate distance trend

Regional interface
- thickness proportional to composite score of trend statistics for all variables

Figure 10. *Regional interface characteristics, TEO system. Bar charts indicate trend statistic values for the top 5 variables.*



Legend

ANNPM
JANPM
JULYPM
ANNMAX
ANNMIN
MAXJULY
MINJAN
ANNTEMP
JANTEMP
JULYTEMP
ANNDD5
GROWLEN
DEMBOUND
KM1DEM
PSNRAW

Strong surficial geology trend
Moderate surficial geology trend
Strong multivariate distance trend
Moderate multivariate distance trend

Regional interface
- thickness proportional to composite score of trend statistics for all variables

Figure 11. *Regional interface characteristics, RTEO system. Bar charts indicate trend statistic values for the top 5 variables.*

specific interfaces in detail, which are beyond the scope of this study. This section outlines general trends observed within and between systems.

The systems show some differences in the dominance of certain variables in their interface trends. Hills system is particularly strong with respect to surficial geology trends. This suggests that although the regions may define climatic and vegetation structure, the boundaries themselves follow geologic trends. It is surprising that the other systems do not show stronger trends for geology because their construction focused more on accurate geologic boundaries through the use of LANDSAT data.

The RTEO system boundaries showed strong temperature variable trends. These variables were less prevalent in the Hills boundaries and even less so in the TEO boundaries. Precipitation trends were found most often in the Hills system with only slightly less representation in the TEO system, followed by the RTEO system.

The RTEO system, however, did show stronger trends in growing season length and growing degree days than the Hills and TEO systems, respectively. This combined with the strong trends in temperature and the strongest trends in NDVI, suggest that the use of LANDSAT data in the construction of the RTEO system focused more on vegetation trends than its predecessor, the TEO system.

These generalizations should not provide the sole basis for selection of a particular system. Local strengths and weaknesses of specific interfaces should be considered, in combination with the regional core results to make decisions about which systems provide the best delineation of the phenomena the user wishes to examine. Rationale for using these systems and the implications for future ecoregionalization work are explored in more detail in Chapter 4.

3.4 Problems Encountered

During this study, some limitations and difficulties were noted, particularly in the base datasets. One notable problem was the high correlation among climate variables. As mentioned, they were all included to provide detailed quantification, however there was often no visible differentiating power among a number of these variables, particularly some of the temperature measures.

Another important limitation was a banding problem associated with the digital elevation model. A histogram of the values of the model shows pronounced steps, which coincide with the contour interval of the base data used to derive it (National Topographic System contour data). The result is bands of similar values around the contours. This problem was noted previously by Graham (1995). Unfortunately, alternate data sources were not available. This source of error affected the construction of the terrain complexity variable, particularly in northern areas where relief changes were small. This makes it difficult to conclude whether the limited role of terrain complexity in most of the analyses was due to banding problems in the data set or because terrain effects are more relevant at finer spatial scales.

The sparse distribution of northern climate base data points limited the accuracy and usefulness of these variables in this area. This was eliminated to some extent in the boundary analyses, where the northernmost boundaries were disregarded, however this does affect the core results in these northern regions.

As mentioned earlier, a bias was introduced favouring large oblique-shaped regions over smaller thinner regions by the core area construction. The buffer width was developed iteratively to find a balance between exclusion of the transition areas and maintaining viable samples in most regions over the 3 systems. This did however eliminate 2 very small regions in the RTEO system, namely 92 and 133, and introduced some uncertainty in the results for other very small and/or narrow regions (7E in the Hills system, 1 and 7 in the TEO system, and 135 in the RTEO system).

CHAPTER 4

Conclusions and Recommendations

This section outlines the major conclusions and recommendations of this study. These are presented in 2 parts: implications for using existing ecoregionalization systems and implications for developing new systems.

4.1 Implications for Using Existing Ecoregionalization Systems

Probably the most significant finding of this study is the lack of a clearly superior system. Superiority depends on the explicit goals of the user of the system. The benefits of one system over another only become evident when the user defines the phenomena that the regions must differentiate. For example, the boundary lines of the Hills system will probably provide more useful delineation of phenomena that are highly dependent on geologic trends. This is made more confusing by the fact that these same regions as units may be more closely associated with climate variations and therefore applicable to phenomena driven by these gradients.

This study has generated a number of tools that can be used to examine these differences at the regional level. Choices of particular boundaries among systems could be made by examining the boundary trend plots and maps in conjunction with the multivariate distance, geologic similarity, or PCA analyses relevant to these exact regions. This may be suitable for very specific, small areas, but making a series of these choices over many regions and large areas amounts to a subjective combination of delineations to define a system for the specific phenomena of study. This is the root of the limitation of using any or all of these systems — a subjective, non-reproducible construction method.

In the quote presented in Section 1.1.1, Hills states that his system was meant to define much broader goals than simply regions of similar commercial timber. The key problem is that in order to meet these broader goals, many different factors were considered and subjectively accommodated to create a more generalized system. This is true of all 3 systems despite the technical advances incorporated in the TEO and RTEO systems. These systems are not testable hypotheses and most importantly are not reproducible.

4.2 Implications for Future Ecoregionalization Development

An explicit, reproducible, and flexible system of regionalization is needed to avoid the limitations in the existing systems. The regionalizations examined here represent huge projects from the points of view of complexity of construction and financial input, mainly because they have tried to incorporate many ecological and land classification goals. More importantly, updating or modifying them with any reproducible logic is nearly impossible without an expert system approach, including the original authors of each system. Ideally, a system that can be tuned to the specific needs of the phenomena the user is studying is needed. For example, a system that is heavily based on temperature gradients isn't useful if the user wants to stratify a strictly terrain-based process or problem.

An interactive system where the user decides which variables are relevant to the phenomena, weights these variables according to their relative importance to this phenomena, and then generates a system by a reproducible, explicit methodology, would be ideal. Subjective improvements could be incorporated later, much like satellite classification. These changes,

however, would be relevant to this specific analysis and would not limit stratification in subsequent analyses for different phenomena. This rationale was adopted in the development of the Hierarchical Ecoregional Framework (Perera et al. 1995). This system provides a means to customize regions to a specific process like primary productivity, using explicit reproducible methods. Development of systems like this will eliminate the limitations of subjective construction methods and allow systematic modification and maintenance as new information becomes available.

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APPENDIX I

Basic Statistics by Region

Basic Statistics - 1km Resolution Hills System

Reg	Variable	Low	High	Mean	StdDev	Skewness	Cv	StdMean
1E	LAT	53.1	56.8	54.7821	0.8226	0.1165	1.5017	0.0023
	LONG	-91.1	-82.1	-86.2175	2.2872	-0.0296	-2.6529	0.0064
	ANNPM	4880.0	6140.0	5510.6360	279.5826	-0.0412	5.0731	0.7865
	JANPM	17.0	28.0	22.7394	2.1932	-0.1248	9.6449	0.0062
	JULYPM	74.0	91.0	85.0370	3.4665	-0.4563	4.0999	0.0098
	ANNMAX	2725.0	2787.0	2746.3060	8.7659	0.0220	0.3192	0.0247
	ANNMIN	2630.0	2650.0	2640.4070	4.1242	-0.0098	0.1562	0.0116
	MAXJULY	2915.0	2945.0	2929.6980	6.7060	0.1676	0.2289	0.0189
	MINJAN	2411.0	2428.0	2420.6510	3.2981	-0.0820	0.1362	0.0093
	ANNTEMP	2679.0	2707.0	2693.3980	6.2828	-0.0674	0.2333	0.0177
	JANTEMP	2466.0	2493.0	2480.3030	5.8683	-0.1855	0.2366	0.0165
	JULYTEMP	2862.0	2891.0	2878.2040	5.6625	-0.0383	0.1967	0.0159
	ANNDD5	697.0	990.0	842.6478	65.0366	0.2193	7.7181	0.1830
	GROWLEN	130.0	157.0	148.1164	3.9319	-0.0855	2.6546	0.0111
	DEMBOUND	1.0	13.0	6.2535	3.3998	-0.1292	54.3659	0.0096
	GEOL1KM	0.0	8.0	7.8542	0.8446	-6.9698	10.7536	0.0024
	KM1DEM	1.0	194.0	78.1038	39.7214	-0.3841	50.8572	0.1144
	KM1ASPCT	1.0	10.0	4.8903	3.0818	0.4991	63.0190	0.0089
	PSNRAW	18.0	567.0	415.5161	45.1776	-1.5502	10.8727	0.1282
2W	LAT	50.1	55.5	53.0648	1.0657	-0.1678	2.0083	0.0026
	LONG	-94.5	-88.1	-89.6327	2.0305	-0.2393	-2.2654	0.0049
	ANNPM	5509.0	7639.0	6679.8570	529.0607	0.1210	7.9202	1.2670
	JANPM	23.0	46.0	32.3571	4.1892	0.2080	12.9467	0.0100
	JULYPM	81.0	106.0	93.9071	5.4546	0.0683	5.8085	0.0131
	ANNMAX	2741.0	2795.0	2764.7040	10.1825	0.1018	0.3683	0.0244
	ANNMIN	2640.0	2665.0	2652.1240	4.6313	0.3724	0.1746	0.0111
	MAXJULY	2932.0	2968.0	2950.2570	7.9856	-0.1045	0.2707	0.0191
	MINJAN	2421.0	2448.0	2430.4840	4.3563	0.5825	0.1792	0.0104
	ANNTEMP	2690.0	2728.0	2708.4770	6.6963	-0.2129	0.2546	0.0165
	JANTEMP	2476.0	2524.0	2493.0080	7.4933	0.3070	0.3006	0.0180
	JULYTEMP	2884.0	2909.0	2897.4020	4.8481	-0.2690	0.1673	0.0116
	ANNDD5	869.0	1273.0	1084.3050	79.9162	-0.2305	7.3703	0.1915
	GROWLEN	148.0	170.0	160.0339	4.1042	-0.2778	2.5646	0.0098
	DEMBOUND	1.0	13.0	7.1087	3.1959	-0.4532	44.9580	0.0077
	GEOL1KM	0.0	8.0	3.5840	2.5471	0.7095	71.0676	0.0061
	KM1DEM	76.0	404.0	235.8105	65.0269	-0.2469	27.5758	0.1569
	KM1ASPCT	1.0	10.0	4.6195	2.8894	0.5082	62.5478	0.0070
	PSNRAW	213.0	678.0	485.2214	41.5657	0.1177	8.5663	0.0996
2E	LAT	49.5	53.6	51.4356	0.9234	0.2010	1.7952	0.0023
	LONG	-96.6	-79.5	-83.2735	1.8908	0.2068	-2.2706	0.0048
	ANNPM	5259.0	8329.0	6583.7310	684.6985	0.5896	10.3999	1.7310
	JANPM	22.0	56.0	37.4702	7.5274	0.0857	20.0890	0.0190
	JULYPM	81.0	105.0	92.9967	5.3300	0.4061	5.7314	0.0135
	ANNMAX	2760.0	2799.0	2780.8190	8.1685	-0.2301	0.2937	0.0207
	ANNMIN	2645.0	2675.0	2657.8540	5.8325	0.3411	0.2195	0.0147
	MAXJULY	2942.0	2972.0	2957.6560	7.2249	0.0608	0.2443	0.0183
	MINJAN	2422.0	2472.0	2441.4700	10.2725	0.1277	0.4208	0.0260
	ANNTEMP	2702.0	2735.0	2719.2140	6.7873	0.0030	0.2496	0.0172
	JANTEMP	2489.0	2535.0	2511.1650	11.1472	-0.1094	0.4439	0.0282
	JULYTEMP	2881.0	2907.0	2894.6630	6.2639	-0.0266	0.2171	0.0159
	ANNDD5	927.0	1310.0	1119.8430	87.6524	0.1088	7.8286	0.2216
	GROWLEN	154.0	173.0	163.6678	4.3634	-0.1835	2.6660	0.0110
	DEMBOUND	1.0	13.0	6.4513	3.2420	-0.2177	50.2541	0.0083
	GEOL1KM	0.0	8.0	7.1325	2.0306	-2.1389	28.4697	0.0051
	KM1DEM	1.0	308.0	112.7963	69.5465	0.5837	61.6567	0.1773
	KM1ASPCT	1.0	10.0	4.6464	3.0110	0.6096	64.8024	0.0077
	PSNRAW	21.0	702.0	524.0755	46.3063	-0.2484	8.8358	0.1173
3S	LAT	50.1	53.2	51.6848	0.6464	-0.0945	1.2507	0.0023
	LONG	-95.2	-89.8	-92.4793	1.3644	-0.1446	-1.4754	0.0049
	ANNPM	6119.0	7879.0	6982.8340	381.9060	0.0560	5.5488	1.3830
	JANPM	30.0	44.0	35.9174	2.5824	0.3994	7.1899	0.0094
	JULYPM	77.0	107.0	91.7999	6.1291	0.1207	6.6768	0.0222
	ANNMAX	2770.0	2795.0	2782.3420	5.5224	-0.0122	0.1985	0.0200
	ANNMIN	2650.0	2686.0	2669.2510	7.1729	0.0044	0.2687	0.0260
	MAXJULY	2956.0	2975.0	2964.9550	4.0156	-0.0389	0.1354	0.0145
	MINJAN	2427.0	2477.0	2449.6780	9.5350	0.4432	0.3892	0.0345
	ANNTEMP	2712.0	2741.0	2725.7660	6.1387	0.2178	0.2252	0.0222
	JANTEMP	2496.0	2534.0	2511.9680	8.2608	0.4367	0.3289	0.0299
	JULYTEMP	2901.0	2923.0	2910.4490	4.0245	0.0591	0.1383	0.0146
	ANNDD5	1151.0	1477.0	1308.4300	69.3015	0.0099	5.2965	0.2510
	GROWLEN	162.0	179.0	170.1951	3.5181	0.0223	2.0671	0.0127
	DEMBOUND	1.0	13.0	7.4075	3.0520	-0.5779	41.2014	0.0111
	GEOL1KM	0.0	8.0	1.9687	1.5479	2.0853	77.8348	0.0056
	KM1DEM	272.0	460.0	373.2496	31.1459	-0.5535	8.3445	0.1135
	KM1ASPCT	1.0	10.0	4.9697	2.7330	0.1930	54.9932	0.0100
	PSNRAW	261.0	606.0	484.5056	40.8471	-1.4845	8.4307	0.1480
3W	LAT	48.4	51.6	49.8093	0.8559	0.2694	1.3168	0.0021
	LONG	-91.7	-85.9	-88.6850	1.4112	0.0901	-1.5913	0.0045
	ANNPM	6539.0	8790.0	7561.1050	341.2320	-0.4741	4.5130	1.0967
	JANPM	27.0	59.0	43.0769	5.6797	1.1915	13.1851	0.0183
	JULYPM	71.0	106.0	91.0978	6.0787	-0.1592	6.6727	0.0195
	ANNMAX	2778.0	2809.0	2792.7600	5.6396	-0.1823	0.2019	0.0181
	ANNMIN	2643.0	2697.0	2663.2930	10.8243	0.4314	0.4064	0.0348
	MAXJULY	2918.0	2977.0	2964.8340	9.7781	-2.0900	0.3297	0.0314
	MINJAN	2420.0	2515.0	2447.9400	17.9470	0.7678	0.7331	0.0577
	ANNTEMP	2712.0	2750.0	2728.0600	7.7777	0.1580	0.2851	0.0250
	JANTEMP	2497.0	2579.0	2523.0870	15.3568	0.7041	0.6087	0.0494
	JULYTEMP	2873.0	2923.0	2901.0540	8.4048	-0.1804	0.2897	0.0270
	ANNDD5	996.0	1494.0	1211.0700	89.4424	0.8728	7.3854	0.2875
	GROWLEN	161.0	180.0	168.8096	3.8217	0.4688	2.2639	0.0123
	DEMBOUND	1.0	13.0	8.0661	2.7204	-0.8657	33.7263	0.0090
	GEOL1KM	0.0	8.0	2.8804	1.8602	0.8728	64.2343	0.0058
	KM1DEM	50.0	548.0	368.3407	66.6107	0.0586	18.0840	0.2193
	KM1ASPCT	1.0	10.0	4.7180	2.4995	0.2809	52.9788	0.0083
	PSNRAW	18.0	729.0	576.2675	77.0144	-1.2260	13.3643	0.2491
3E	LAT	47.6	50.2	48.9093	0.6613	0.0942	1.3521	0.0018
	LONG	-86.3	-79.5	-82.8837	1.7790	0.0256	-2.1464	0.0049
	ANNPM	6519.0	10330.0	8227.8550	619.0436	-0.1375	7.5238	1.7195
	JANPM	45.0	84.0	57.8481	7.1362	1.0640	12.3387	0.0198
	JULYPM	78.0	108.0	89.8681	5.6957	0.5435	6.3522	0.0158
	ANNMAX	2786.0	2811.0	2798.8430	4.9073	0.2414	0.1753	0.0136
	ANNMIN	2660.0	2702.0	2674.7300	8.4104	0.2997	0.2397	0.0176
	MAXJULY	2925.0	2981.0	2966.2170	9.5650	-1.6370	0.3231	0.0266
	MINJAN	2450.0	2526.0	2473.2770	11.5964	0.6077	0.4689	0.0322
	ANNTEMP	2723.0	2755.0	2736.8940	5.1779	0.0275	0.1892	0.0144
	JANTEMP	2522.0	2588.0	2543.9290	10.8227	0.3951	0.4254	0.0301
	JULYTEMP	2874.0	2916.0	2901.7120	7.1534	-0.8879	0.2465	0.0199
	ANNDD5	997.0	1467.0	1279.1830	77.3858	0.0100	6.0496	0.2150
	GROWLEN	167.0	184.0	172.7405	2.4140	0.3822	1.3975	0.0067
	DEMBOUND	1.0	13.0	7.8850	2.8446	-0.7596	36.0763	0.0079
	GEOL1KM	0.0	8.0	3.3795	1.9352	0.6265	57.2628	0.0054
	KM1DEM	63.0	548.0	298.2319	70.2587	-0.0180	23.5584	0.1951
	KM1ASPCT	1.0	10.0	4.7406	2.7026	0.2494	57.0101	0.0075
	PSNRAW	129.0	631.0	480.2456	56.2070	-1.1786	8.5568	0.1619

Reg Variable	Low	High	Mean	StdDev	Skewness	Cv	StdMean
7E LAT	41.9	44.3	43.0501	0.5686	0.4601	1.3231	0.0034
LONG	-83.1	-76.2	-80.5534	1.6341	0.5309	-2.0286	0.0098
ANNPM	7739.0	10160.0	9046.1220	510.6373	-0.2919	5.6481	3.0669
JANPM	46.0	92.0	60.3564	8.6285	0.4641	14.2956	0.0518
JULYPM	54.0	83.0	72.5762	6.7756	-0.7762	9.3351	0.0407
ANNMAX	2638.0	2868.0	2854.2940	5.4910	-0.1140	0.1924	0.0329
ANNMIN	2742.0	2783.0	2765.5320	7.6841	-0.0248	0.2779	0.0461
MAXJULY	2978.0	3007.0	2994.5990	5.6151	-0.0610	0.1875	0.0337
MINJAN	2568.0	2646.0	2623.8090	11.8550	-0.9046	0.4519	0.0711
ANNTEMP	2790.0	2823.0	2809.9810	6.4149	-0.1119	0.2283	0.0385
JANTEMP	2636.0	2663.0	2644.9710	8.5689	-0.6600	0.3218	0.0514
JULYTEMP	2930.0	2959.0	2944.8290	5.6895	0.5109	0.1925	0.0340
ANNDD5	1684.0	2551.0	2228.6030	128.9552	0.4022	5.7864	0.7735
GROWLEN	215.0	243.0	231.2760	4.8763	-0.0900	2.1084	0.0253
DEMBOUND	1.0	13.0	6.6376	3.1920	-0.4215	48.0862	0.0192
GEOL1KM	0.0	10.0	4.4710	2.1070	0.2297	47.1247	0.0126
KM1DEM	63.0	319.0	161.2344	43.2306	-0.9781	23.8534	0.2598
KM1ASPCT	1.0	10.0	5.4009	2.6918	0.2251	49.8394	0.0165
PSNRAW	195.0	759.0	622.0740	59.5386	-2.1319	9.5710	0.3429

Basic Statistics - 1km Resolution RTEO System

Reg	Variable	Low	High	Mean	StdDev	Skewness	Cv	StdMean
89	LAT	52.7	54.9	53.5736	0.4620	0.5101	0.8896	0.0026
	LONG	-94.8	-91.4	-92.7737	0.8108	-0.5065	-0.8740	0.0048
	ANNPM	5750.0	6900.0	6341.1710	178.7122	-0.1011	2.8183	1.0576
	JANPM	26.0	35.0	31.2933	1.5848	-0.6025	5.0644	0.0094
	JULYPM	83.0	96.0	88.7583	2.2453	0.2737	2.5297	0.0133
	ANNMAX	2748.0	2776.0	2764.5980	6.2324	-0.1726	0.2254	0.0369
	ANNMIN	2645.0	2665.0	2656.0620	5.0886	-0.0204	0.1916	0.0302
	MAXJULY	2940.0	2962.0	2952.1950	4.8405	-0.1684	0.1640	0.0287
	MINJAN	2422.0	2443.0	2433.0080	4.2658	0.0527	0.1753	0.0253
	ANNTEMP	2697.0	2721.0	2710.3280	5.5925	-0.1037	0.2063	0.0332
	JANTEMP	2479.0	2504.0	2492.5620	5.1671	-0.0826	0.2081	0.0308
	JULYTEMP	2890.0	2910.0	2901.4180	4.3843	-0.0772	0.1511	0.0260
	ANNDD5	961.0	1288.0	1137.6140	73.5450	0.0160	6.4649	0.4360
	GROWLEN	153.0	169.0	162.5692	3.5706	-0.0838	2.1964	0.0212
	DEMBOUND	1.0	13.0	7.5183	3.1034	-0.6012	41.2782	0.0186
	GEOL1KM	0.0	8.0	3.9519	2.4536	-0.0363	62.0922	0.0145
	KM1DEM	126.0	359.0	268.5763	34.3747	-0.8809	12.8949	0.2055
	KM1ASPCT	1.0	10.0	4.7564	2.8088	0.3001	59.0531	0.0170
	PSNRAW	234.0	555.0	485.2797	32.6931	-1.9898	6.7370	0.1944
90	LAT	49.9	53.1	51.4333	0.7553	0.0942	1.4685	0.0022
	LONG	-95.2	-88.7	-92.5580	1.5585	0.2652	-1.6817	0.0045
	ANNPM	5569.0	7879.0	6822.8290	459.8202	0.2167	6.7394	1.3337
	JANPM	24.0	44.0	35.0964	3.6157	0.0836	10.3023	0.0105
	JULYPM	75.0	107.0	91.0128	7.1138	0.1408	7.8163	0.0206
	ANNMAX	2767.0	2805.0	2785.2830	8.1251	0.2012	0.2917	0.0236
	ANNMIN	2646.0	2695.0	2671.4670	10.7457	-0.1115	0.4022	0.0312
	MAXJULY	2953.0	2982.0	2967.0140	5.9062	0.2013	0.1991	0.0171
	MINJAN	2422.0	2487.0	2452.7140	13.6798	0.1973	0.5576	0.0397
	ANNTEMP	2711.0	2747.0	2728.3580	9.1455	0.1749	0.3352	0.0265
	JANTEMP	2494.0	2544.0	2515.2950	11.6904	0.3506	0.4648	0.0339
	JULYTEMP	2897.0	2925.0	2911.7350	5.9509	-0.0828	0.2044	0.0173
	ANNDD5	1102.0	1606.0	1338.5220	110.8312	0.1333	8.2801	0.3215
	GROWLEN	161.0	185.0	171.8569	5.6913	0.1597	3.3117	0.0165
	DEMBOUND	1.0	13.0	7.5130	2.9825	-0.6203	39.6983	0.0087
	GEOL1KM	0.0	8.0	2.3867	1.8836	1.3828	78.5879	0.0055
	KM1DEM	262.0	460.0	368.0836	31.1899	-0.4330	8.4736	0.0914
	KM1ASPCT	1.0	10.0	4.9591	2.6752	0.1695	53.9440	0.0079
	PSNRAW	261.0	642.0	484.0835	44.9127	-1.1748	9.2779	0.1304
91	LAT	48.6	50.4	49.5194	0.3860	-0.1632	0.7795	0.0021
	LONG	-95.2	-91.7	-93.5111	0.9038	0.0071	-0.9665	0.0049
	ANNPM	5570.0	7220.0	6548.7800	391.5560	-0.6180	5.9791	2.1442
	JANPM	23.0	35.0	29.6734	2.0674	0.1855	7.0346	0.0114
	JULYPM	76.0	97.0	88.8662	4.8814	-0.6564	5.4930	0.0267
	ANNMAX	2795.0	2815.0	2805.1760	3.7616	0.1630	0.1341	0.0206
	ANNMIN	2684.0	2700.0	2693.3730	3.3281	-0.5871	0.1236	0.0182
	MAXJULY	2973.0	2986.0	2979.9040	2.3928	-0.2554	0.0803	0.0131
	MINJAN	2462.0	2492.0	2481.3470	6.1895	-0.7952	0.2494	0.0339
	ANNTEMP	2741.0	2757.0	2749.2280	3.0834	0.1306	0.1122	0.0169
	JANTEMP	2529.0	2555.0	2542.7920	4.9225	-0.1452	0.1936	0.0270
	JULYTEMP	2919.0	2928.0	2923.6680	1.6073	0.1859	0.0550	0.0088
	ANNDD5	1487.0	1668.0	1593.5610	39.3821	-0.1564	2.4713	0.2157
	GROWLEN	179.0	189.0	184.1758	1.9796	-0.3132	1.0750	0.0108
	DEMBOUND	1.0	13.0	7.3473	2.8533	-0.6192	38.8343	0.0157
	GEOL1KM	0.0	6.0	2.2294	1.6139	1.3640	72.3945	0.0088
	KM1DEM	284.0	469.0	366.7628	30.4129	0.4519	8.2923	0.1674
	KM1ASPCT	1.0	10.0	5.0570	2.6076	0.0673	51.5645	0.0146
	PSNRAW	312.0	636.0	516.3165	49.4653	-0.4027	9.5804	0.2719
92	LAT	48.5	49.2	0.1649	0.2592	0.3377	0.0026	
	LONG	-94.8	-93.3	0.3631	0.4177	-0.3855	0.0058	
	ANNPM	6229.0	7089.0	245.1353	-0.1541	3.8447	3.9364	
	JANPM	29.0	34.0	1.2402	0.4247	4.0128	0.0199	
	JULYPM	85.0	92.0	1.7510	0.0686	1.9762	0.0281	
	ANNMAX	2810.0	2816.0	1.3410	0.6295	0.0477	0.0215	
	ANNMIN	2692.0	2700.0	1.4879	0.3012	0.0552	0.0239	
	MAXJULY	2982.0	2986.0	1.3268	0.5889	0.0445	0.0213	
	MINJAN	2478.0	2492.0	2.6819	0.4588	0.1139	0.0463	
	ANNTEMP	2752.0	2757.0	1.3031	-0.1798	0.0473	0.0209	
	JANTEMP	2544.0	2555.0	2.4272	0.7241	0.0952	0.0390	
	JULYTEMP	2923.0	2926.0	0.5847	0.4328	0.0200	0.0094	
	ANNDD5	1627.0	1686.0	9.1681	0.0615	0.5523	0.1472	
	GROWLEN	186.0	190.0	0.7184	0.1655	0.3829	0.0115	
	DEMBOUND	1.0	13.0	3.3704	0.0326	60.4879	0.0569	
	GEOL1KM	0.0	6.0	2.0302	0.7245	75.6716	0.0326	
	KM1DEM	327.0	384.0	11.8361	1.3098	3.4544	0.1998	
	KM1ASPCT	1.0	10.0	2.6746	-0.1428	43.4456	0.0473	
	PSNRAW	57.0	636.0	96.4749	-4.5220	16.6687	1.5951	
93	LAT	48.0	49.9	0.4123	0.7830	0.8468	0.0024	
	LONG	-92.9	-88.9	0.8918	[illegible]	-0.9785	0.0053	
	ANNPM	6180.0	8359.0	461.2816	-0.[illegible]20	6.1389	2.7275	
	JANPM	24.0	50.0	5.0728	-0.5427	15.2160	0.0359	
	JULYPM	85.0	102.0	2.8302	-1.0243	2.9616	0.0167	
	ANNMAX	2796.0	2818.0	4.5012	-0.0806	0.1603	0.0266	
	ANNMIN	2663.0	2697.0	6.5623	-0.0527	0.2446	0.0388	
	MAXJULY	2961.0	2993.0	4.1690	-0.3614	0.1401	0.0246	
	MINJAN	2456.0	2512.0	9.0538	1.0128	0.3656	0.0535	
	ANNTEMP	2732.0	2757.0	4.7512	0.2335	0.1731	0.0281	
	JANTEMP	2531.0	2577.0	8.0150	0.8944	0.3148	0.0474	
	JULYTEMP	2895.0	2924.0	7.2699	-0.2194	0.2497	0.0430	
	ANNDD5	1171.0	1645.0	104.9030	-0.1494	7.3583	0.6202	
	GROWLEN	168.0	188.0	4.1059	-0.0875	2.2906	0.0243	
	DEMBOUND	1.0	13.0	2.6735	-0.9262	33.4071	0.0158	
	GEOL1KM	0.0	7.0	1.8791	1.2953	63.1217	0.0111	
	KM1DEM	184.0	610.0	55.4981	-1.1786	13.2812	0.3282	
	KM1ASPCT	1.0	10.0	2.4668	0.0412	49.3501	0.0147	
	PSNRAW	429.0	711.0	59.6542	0.5156	10.3839	0.3561	
94	LAT	48.3	51.4	0.8318	0.1683	1.2696	0.0021	
	LONG	-91.8	-85.7	1.3585	0.0556	-1.5317	0.0045	
	ANNPM	6509.0	8689.0	329.6888	-0.6805	4.3845	1.0953	
	JANPM	27.0	67.0	4.8152	1.0221	11.2296	0.0160	
	JULYPM	71.0	103.0	5.8339	-0.3022	6.4220	0.0194	
	ANNMAX	2778.0	2810.0	5.4997	-0.0833	0.1969	0.0183	
	ANNMIN	2643.0	2695.0	10.6060	0.4048	0.3982	0.0352	
	MAXJULY	2918.0	2976.0	9.5241	-2.1041	0.3212	0.0316	
	MINJAN	2420.0	2512.0	17.4382	0.8972	0.7124	0.0579	
	ANNTEMP	2712.0	2752.0	7.6104	0.1320	0.2790	0.0253	
	JANTEMP	2498.0	2576.0	14.7833	0.6868	0.5859	0.0491	
	JULYTEMP	2873.0	2923.0	8.3591	-0.0795	0.2881	0.0278	
	ANNDD5	996.0	1502.0	89.4828	0.8416	7.3915	0.2973	
	GROWLEN	161.0	180.0	3.0613	0.4486	2.1687	0.0122	
	DEMBOUND	1.0	13.0	2.7407	-0.8548	34.1116	0.0093	
	GEOL1KM	0.0	8.0	1.8507	0.8796	64.3047	0.0061	
	KM1DEM	50.0	548.0	67.7378	0.0276	18.3296	0.2309	
	KM1ASPCT	1.0	10.0	2.5039	0.2856	52.9471	0.0086	
	PSNRAW	18.0	729.0	75.9844	-1.3963	13.1855	0.2543	

Reg	Variable	Low	High	Mean	StdDev	Skewness	Cv	StdMean
95	LAT	50.2	55.0	52.7496	1.1193	-0.1577	2.1219	0.0032
	LONG	-92.0	-85.7	-88.8934	1.5617	-0.0282	-1.7456	0.0045
	ANNPM	5696.0	7829.0	6830.0180	473.8670	-0.3189	6.9380	1.3609
	JANPM	24.0	45.0	33.3701	4.1350	-0.0014	12.3913	0.0119
	JULYPM	83.0	106.0	95.2529	4.9255	-0.2105	5.1710	0.0141
	ANNMAX	2746.0	2795.0	2768.7160	11.1685	0.3544	0.4037	0.0321
	ANNMIN	2643.0	2685.0	2652.0070	3.8476	0.1233	0.1451	0.0111
	MAXJULY	2935.0	2971.0	2951.4250	8.2937	0.1369	0.2810	0.0238
	MINJAN	2422.0	2453.0	2430.6500	4.4241	0.9828	0.1820	0.0127
	ANNTEMP	2695.0	2731.0	2709.4390	7.1767	0.1433	0.2649	0.0206
	JANTEMP	2479.0	2527.0	2494.6440	8.8606	0.7501	0.3552	0.0254
	JULYTEMP	2888.0	2905.0	2897.5010	3.8485	-0.5886	0.1328	0.0110
	ANNDD5	924.0	1271.0	1088.5170	71.0486	-0.2360	6.5269	0.2040
	GROWLEN	151.0	171.0	160.3756	3.8443	0.0079	2.3970	0.0110
	DEMBOUND	1.0	13.0	7.0339	3.2177	-0.4366	45.7461	0.0093
	GEOL1KM	0.0	8.0	2.7278	1.9661	1.6238	72.0763	0.0056
	KM1DEM	76.0	413.0	239.0728	54.8206	-0.0449	22.9395	0.1588
	KM1ASPCT	1.0	10.0	4.5241	2.9006	0.6107	64.1141	0.0085
	PSNRAW	213.0	687.0	483.7116	49.1799	0.4041	9.9813	0.1412
96	LAT	47.4	50.5	49.1901	0.6103	-0.0771	1.2406	0.0018
	LONG	-86.4	-79.5	-82.9331	1.9807	0.0759	-2.3883	0.0057
	ANNPM	6499.0	10330.0	8168.0230	652.1419	0.0613	7.9841	1.8936
	JANPM	44.0	84.0	57.3390	8.0286	0.9283	14.0019	0.0233
	JULYPM	78.0	106.0	91.4918	6.8373	0.3033	7.4731	0.0199
	ANNMAX	2778.0	2808.0	2795.8940	5.2350	-0.8095	0.1872	0.0152
	ANNMIN	2650.0	2702.0	2671.8150	7.6664	0.0794	0.2869	0.0223
	MAXJULY	2918.0	2980.0	2963.2890	9.7127	-1.4264	0.3278	0.0282
	MINJAN	2440.0	2526.0	2488.1540	13.3813	0.7244	0.5419	0.0389
	ANNTEMP	2713.0	2755.0	2734.0090	6.0873	-0.7077	0.2227	0.0177
	JANTEMP	2513.0	2588.0	2539.9130	12.0877	0.5832	0.4759	0.0351
	JULYTEMP	2874.0	2914.0	2898.9470	7.0504	-0.7044	0.2432	0.0206
	ANNDD5	997.0	1434.0	1240.8130	75.4094	-0.2721	6.0774	0.2190
	GROWLEN	161.0	184.0	171.4828	2.8481	-0.5204	1.6609	0.0083
	DEMBOUND	1.0	13.0	7.7497	2.9337	-0.7118	37.8551	0.0085
	GEOL1KM	0.0	8.0	3.4174	1.9757	0.5849	57.8135	0.0057
	KM1DEM	63.0	548.0	283.2252	65.7302	0.3408	23.2078	0.1909
	KM1ASPCT	1.0	10.0	4.8221	2.7481	0.2226	56.9888	0.0080
	PSNRAW	129.0	819.0	654.7002	88.2847	-0.9573	10.4299	0.1985
97	LAT	46.4	48.9	47.4315	0.5360	0.1105	1.1343	0.0018
	LONG	-85.0	-79.3	-82.0967	1.4498	0.0267	-1.7658	0.0049
	ANNPM	7249.0	11440.0	8991.5940	718.1143	1.1848	7.9885	2.4240
	JANPM	45.0	96.0	64.1341	10.2540	1.2693	15.9884	0.0346
	JULYPM	67.0	98.0	83.3744	4.8834	-0.3066	5.8572	0.0165
	ANNMAX	2796.0	2831.0	2810.8820	5.5357	0.4961	0.1969	0.0187
	ANNMIN	2673.0	2725.0	2689.9240	8.6662	0.7542	0.3222	0.0293
	MAXJULY	2943.0	2990.0	2974.6000	6.7517	-1.7790	0.2270	0.0228
	MINJAN	2470.0	2573.0	2498.7400	16.5150	1.0165	0.6609	0.0557
	ANNTEMP	2736.0	2775.0	2750.3510	6.9709	0.6829	0.2535	0.0235
	JANTEMP	2543.0	2623.0	2567.6470	13.9518	0.8464	0.5434	0.0471
	JULYTEMP	2887.0	2930.0	2910.6460	6.2660	-0.9974	0.2153	0.0212
	ANNDD5	1149.0	1741.0	1426.5870	87.4490	-0.0671	6.1297	0.2952
	GROWLEN	170.0	203.0	180.1321	5.1285	1.1111	2.8460	0.0173
	DEMBOUND	1.0	13.0	8.3725	2.4636	-0.7988	29.4249	0.0083
	GEOL1KM	0.0	8.0	2.8447	1.8093	1.2761	56.5724	0.0054
	KM1DEM	116.0	568.0	370.9205	65.1457	-0.2950	17.5632	0.2203
	KM1ASPCT	1.0	10.0	4.6667	2.3944	0.1711	51.3074	0.0081
	PSNRAW	615.0	837.0	743.1715	35.9999	-0.0151	4.8441	0.1217
98	LAT	44.4	46.9	45.6488	0.5644	-0.1157	1.3022	0.0021
	LONG	-84.1	-76.1	-79.1131	1.6360	-0.5508	-2.0679	0.0058
	ANNPM	7799.0	11359.0	9463.4990	825.4935	0.4415	8.7229	2.9532
	JANPM	48.0	112.0	70.5548	14.6367	0.8402	20.7452	0.0524
	JULYPM	90.0	102.0	78.8688	9.1327	0.3951	11.5796	0.0327
	ANNMAX	2813.0	2846.0	2829.2550	5.7431	0.1384	0.2030	0.0205
	ANNMIN	2697.0	2750.0	2716.6430	9.5099	0.7041	0.3501	0.0340
	MAXJULY	2972.0	2997.0	2982.8970	4.6553	0.5863	0.1561	0.0167
	MINJAN	2512.0	2586.0	2540.1080	14.3529	0.5904	0.5651	0.0513
	ANNTEMP	2757.0	2798.0	2772.9300	7.3315	0.6275	0.2644	0.0262
	JANTEMP	2577.0	2637.0	2601.4140	11.6120	0.4680	0.4464	0.0415
	JULYTEMP	2910.0	2944.0	2922.8870	5.9216	0.7289	0.2026	0.0212
	ANNDD5	1458.0	2104.0	1702.8030	110.3400	0.8687	6.4799	0.3947
	GROWLEN	183.0	222.0	200.1762	7.7797	0.1567	3.8864	0.0278
	DEMBOUND	1.0	13.0	8.1287	2.4563	-0.8500	30.2171	0.0088
	GEOL1KM	0.0	9.0	2.2796	1.4382	1.7993	63.1373	0.0051
	KM1DEM	68.0	518.0	270.5255	81.3834	0.4431	29.1148	0.2929
	KM1ASPCT	1.0	10.0	4.7063	2.3205	0.1190	49.3058	0.0084
	PSNRAW	471.0	870.0	771.0959	40.1275	-1.2429	5.2040	0.1444
132	LAT	44.5	45.9	45.1868	0.2894	-0.1440	0.6404	0.0023
	LONG	-77.3	-74.4	-75.6007	0.6522	-0.2294	-0.8627	0.0053
	ANNPM	7739.0	9900.0	9133.4950	542.9382	-0.7973	5.9445	4.3857
	JANPM	45.0	69.0	50.1464	4.6789	-0.7356	7.7791	0.0378
	JULYPM	69.0	89.0	80.6315	5.0723	-0.7435	6.2908	0.0410
	ANNMAX	2835.0	2848.0	2839.4700	2.6239	0.5588	0.0924	0.0212
	ANNMIN	2717.0	2752.0	2736.4450	7.0678	-0.8795	0.2579	0.0570
	MAXJULY	2990.0	2997.0	2994.7300	1.5816	-0.7673	0.0528	0.0128
	MINJAN	2527.0	2585.0	2559.5510	10.8390	-0.7515	0.4183	0.0861
	ANNTEMP	2775.0	2800.0	2787.9370	4.6940	-0.2995	0.1684	0.0379
	JANTEMP	2593.0	2636.0	2614.2570	7.8788	-0.0945	0.3014	0.0636
	JULYTEMP	2929.0	2947.0	2939.2000	3.5905	-0.7936	0.1222	0.0290
	ANNDD5	1796.0	2177.0	2007.0950	70.6079	-0.5825	3.5179	0.5702
	GROWLEN	203.0	224.0	214.6531	3.8098	-0.6785	1.7748	0.0308
	DEMBOUND	1.0	13.0	6.6960	3.1666	-0.5287	47.2911	0.0256
	GEOL1KM	0.0	9.0	5.6119	2.4375	-0.1654	43.4346	0.0197
	KM1DEM	16.0	183.0	88.1502	29.4384	0.3560	33.3957	0.2378
	KM1ASPCT	1.0	10.0	4.7856	3.0215	0.4942	63.1377	0.0245
	PSNRAW	516.0	810.0	722.0858	33.7095	-1.8300	4.6683	0.2736
133	LAT	44.0	44.8	44.4647	0.0695	0.0617	0.1563	0.0021
	LONG	-76.4	-75.8	-76.1037	0.1317	0.1731	-0.1731	0.0040
	ANNPM	9190.0	9649.0	9420.1850	114.4989	-0.3096	1.2155	3.5185
	JANPM	62.0	72.0	66.7590	2.2594	0.2155	3.3844	0.0693
	JULYPM	66.0	79.0	72.7996	2.8150	-0.0593	3.8667	0.0865
	ANNMAX	2845.0	2848.0	2846.7040	1.0675	0.2375	0.0375	0.0328
	ANNMIN	2746.0	2756.0	2751.7660	2.3121	-0.3482	0.0840	0.0710
	MAXJULY	2993.0	2996.0	2994.9100	0.9907	-0.9312	0.0331	0.0304
	MINJAN	2576.0	2591.0	2585.1850	3.1228	-0.3542	0.1208	0.0958
	ANNTEMP	2795.0	2803.0	2799.2030	1.4498	-1.2853	0.0518	0.0445
	JANTEMP	2629.0	2641.0	2636.6030	2.7111	-0.3295	0.1028	0.0832
	JULYTEMP	2942.0	2948.0	2945.2430	1.1574	-0.5305	0.0393	0.0355
	ANNDD5	2083.0	2187.0	2140.3150	24.4890	-0.3456	1.1442	0.7515
	GROWLEN	220.0	226.0	223.3814	1.3883	-0.4308	0.6290	0.0429
	DEMBOUND	1.0	12.0	5.8134	3.2239	-0.1290	55.4563	0.0990
	GEOL1KM	0.0	9.0	3.3804	2.1787	0.9536	64.4509	0.0669
	KM1DEM	76.0	136.0	94.1244	8.7698	2.3582	9.3173	0.2692
	KM1ASPCT	1.0	10.0	5.5201	2.8462	0.2655	51.5608	0.0891
	PSNRAW	689.0	759.0	733.0657	12.7274	0.1980	1.7362	0.3928

Reg	Variable	Low	High	Mean	StdDev	Skewness	Cv	StdMean
134	LAT	43.1	46.3	44.2554	0.5990	1.0731	1.3534	0.0026
	LONG	-84.1	-76.2	-79.9286	1.5560	0.2868	-1.9467	0.0067
	ANNPM	7590.0	10870.0	9452.2850	732.3723	0.0774	7.7481	3.1746
	JANPM	42.0	118.0	78.6760	16.8754	0.4774	21.4492	0.0731
	JULYPM	54.0	83.0	71.4219	6.7654	-0.7113	9.4725	0.0293
	ANNMAX	2821.0	2853.0	2839.6290	5.7696	-0.8286	0.2032	0.0250
	ANNMIN	2717.0	2765.0	2743.7210	7.7018	-0.3562	0.2807	0.0334
	MAXJULY	2957.0	2998.0	2984.2600	7.5403	-1.0993	0.2527	0.0327
	MINJAN	2555.0	2625.0	2583.7600	14.5852	-0.2480	0.5623	0.0632
	ANNTEMP	2771.0	2806.0	2791.6780	6.4271	-0.4985	0.2302	0.0278
	JANTEMP	2612.0	2662.0	2640.3960	10.1974	-0.1665	0.3862	0.0442
	JULYTEMP	2914.0	2945.0	2930.3900	6.8080	-0.4211	0.2323	0.0295
	ANNDD5	1564.0	2183.0	1907.3460	119.8425	-0.4790	6.2832	0.5194
	GROWLEN	198.0	231.0	217.2647	5.4218	-0.4929	2.4955	0.0235
	DEMBOUND	1.0	13.0	7.9952	2.5810	-0.8373	32.0319	0.0117
	GEOL1KM	0.0	10.0	4.1614	2.7534	0.6979	66.1641	0.0119
	KM1DEM	66.0	526.0	269.3853	97.9456	0.2444	36.3616	0.4457
	KM1ASPCT	1.0	10.0	5.0789	2.3644	-0.0426	46.5526	0.0109
	PSNRAW	204.0	828.0	693.7076	60.6267	-3.1637	8.7395	0.2690
135	LAT	41.9	44.1	42.9441	0.4371	0.2695	1.0178	0.0026
	LONG	-83.1	-78.8	-80.9560	1.1329	0.0245	-1.3994	0.0067
	ANNPM	7720.0	10180.0	9090.7220	572.0009	-0.2890	6.2921	3.3947
	JANPM	43.0	83.0	59.6398	8.2703	0.4294	13.8671	0.0491
	JULYPM	62.0	85.0	75.2448	4.4814	-0.2874	5.9558	0.0266
	ANNMAX	2638.0	2668.0	2654.7270	4.7247	0.3087	0.1655	0.0280
	ANNMIN	2741.0	2783.0	2765.2390	7.8153	-0.0631	0.2826	0.0464
	MAXJULY	2978.0	3007.0	2995.7040	4.4168	0.3058	0.1474	0.0262
	MINJAN	2588.0	2646.0	2624.7570	9.8141	-0.6797	0.3663	0.0570
	ANNTEMP	2790.0	2823.0	2810.0580	6.0690	0.0245	0.2167	0.0361
	JANTEMP	2636.0	2683.0	2664.4600	7.6080	-0.4540	0.2856	0.0451
	JULYTEMP	2932.0	2959.0	2944.9000	5.4051	0.8286	0.1835	0.0321
	ANNDD5	1907.0	2551.0	2230.4540	121.5838	0.6745	5.4511	0.7212
	GROWLEN	215.0	243.0	231.1743	4.8472	-0.0710	2.0968	0.0288
	DEMBOUND	1.0	13.0	6.8390	3.1471	-0.5035	46.0178	0.0187
	GEOL1KM	0.0	10.0	4.0997	2.0007	0.3494	48.8023	0.0119
	KM1DEM	67.0	360.0	204.4776	42.1112	-0.0813	20.5945	0.2501
	KM1ASPCT	1.0	10.0	5.3149	2.6612	0.2581	50.0701	0.0160
	PSNRAW	195.0	747.0	621.1208	57.9129	-2.2036	9.3239	0.3629
215	LAT	54.4	56.8	55.5028	0.5465	0.4211	0.9847	0.0029
	LONG	-89.6	-82.2	-86.3372	2.0576	0.4368	-2.3833	0.0108
	ANNPM	4899.0	5730.0	5235.3790	186.9206	0.6000	3.5703	0.9768
	JANPM	17.0	24.0	20.3353	1.2689	0.4347	6.2399	0.0066
	JULYPM	74.0	87.0	81.4063	2.5184	-0.2815	3.0937	0.0132
	ANNMAX	2725.0	2750.0	2739.1760	5.5776	-0.4234	0.2036	0.0292
	ANNMIN	2631.0	2643.0	2637.2110	2.2550	-0.8575	0.0855	0.0118
	MAXJULY	2915.0	2931.0	2922.6730	3.0590	-0.0632	0.1047	0.0160
	MINJAN	2413.0	2423.0	2419.3410	2.0824	-0.6417	0.0861	0.0109
	ANNTEMP	2679.0	2695.0	2688.2140	3.8187	-0.7724	0.1421	0.0200
	JANTEMP	2467.0	2485.0	2478.6360	4.2662	-0.3121	0.1723	0.0223
	JULYTEMP	2862.0	2880.0	2873.2320	3.7509	-0.6421	0.1305	0.0196
	ANNDD5	687.0	859.0	779.6937	30.8052	-0.0378	3.9509	0.1610
	GROWLEN	138.0	149.0	144.3056	2.2178	-0.6722	1.5369	0.0116
	DEMBOUND	1.0	13.0	6.5331	3.3685	-0.2184	51.5613	0.0189
	GEOL1KM	0.0	8.0	7.9367	0.4869	-12.6096	6.1345	0.0025
	KM1DEM	1.0	125.0	41.9719	31.7631	0.5302	75.6772	0.1778
	KM1ASPCT	1.0	10.0	4.2413	3.1213	0.7981	73.5935	0.0177
	PSNRAW	18.0	534.0	390.1591	52.5293	-2.8319	13.4636	0.2817

Reg	Variable	Low	High	Mean	StdDev	Skewness	Cv	StdMean
216	LAT	53.1	56.5	54.5489	0.6898	0.2372	1.2646	0.0022
	LONG	-92.0	-82.1	-86.6161	2.5768	-0.0306	-2.9773	0.0083
	ANNPM	5049.0	6300.0	5640.0510	235.1466	0.0304	4.1692	0.7537
	JANPM	19.0	28.0	23.8397	1.6524	-0.3048	6.9311	0.0053
	JULYPM	77.0	93.0	86.4075	2.7227	-0.3300	3.1510	0.0087
	ANNMAX	2728.0	2767.0	2748.7200	7.5694	-0.1709	0.2754	0.0243
	ANNMIN	2630.0	2650.0	2641.9160	3.9144	-0.4790	0.1482	0.0126
	MAXJULY	2918.0	2943.0	2932.6890	5.2165	-0.1552	0.1779	0.0167
	MINJAN	2411.0	2431.0	2421.4620	3.5594	-0.3441	0.1470	0.0114
	ANNTEMP	2680.0	2707.0	2695.3540	5.4398	-0.4584	0.2018	0.0174
	JANTEMP	2466.0	2493.0	2481.5370	5.3741	-0.5059	0.2166	0.0172
	JULYTEMP	2867.0	2892.0	2880.9420	5.3633	-0.1528	0.1862	0.0172
	ANNDD5	740.0	1002.0	873.4113	57.5749	-0.1429	6.5920	0.1846
	GROWLEN	139.0	157.0	149.8073	3.2355	-0.5160	2.1598	0.0104
	DEMBOUND	1.0	13.0	6.2138	3.3858	-0.1194	54.4875	0.0109
	GEOL1KM	0.0	8.0	7.7842	1.0572	-5.3842	13.5807	0.0034
	KM1DEM	1.0	194.0	93.9067	33.7234	-0.8449	35.9117	0.1086
	KM1ASPCT	1.0	10.0	5.1040	3.0280	0.4012	59.3265	0.0098
	PSNRAW	166.0	567.0	427.8522	36.7506	-0.0499	8.5896	0.1179
217	LAT	50.0	53.9	51.7200	0.9539	0.2495	1.8444	0.0024
	LONG	-87.9	-79.5	-83.6577	1.8292	0.2103	-2.1865	0.0047
	ANNPM	5259.0	6060.0	5432.3720	543.5257	0.3221	9.4498	1.3901
	JANPM	22.0	56.0	35.7914	7.2141	0.2945	20.1558	0.0185
	JULYPM	81.0	105.0	92.3649	4.4227	0.4160	4.7883	0.0113
	ANNMAX	2755.0	2799.0	2778.8760	9.4463	-0.2587	0.3400	0.0242
	ANNMIN	2643.0	2676.0	2656.9930	6.2613	0.4698	0.2357	0.0160
	MAXJULY	2940.0	2972.0	2956.3670	7.8517	0.0540	0.2656	0.0201
	MINJAN	2422.0	2473.0	2439.6930	10.7485	0.4435	0.4405	0.0275
	ANNTEMP	2702.0	2736.0	2717.8410	7.6136	0.0579	0.2801	0.0195
	JANTEMP	2487.0	2536.0	2508.6150	11.8954	0.1234	0.4742	0.0304
	JULYTEMP	2860.0	2907.0	2894.3990	8.2044	0.0041	0.2144	0.0159
	ANNDD5	923.0	1321.0	1108.1240	91.5834	0.2463	8.2647	0.2342
	GROWLEN	153.0	173.0	162.8613	4.6425	0.0289	2.8506	0.0119
	DEMBOUND	1.0	13.0	6.3995	3.2522	-0.1912	50.8204	0.0084
	GEOL1KM	0.0	8.0	7.5412	1.5656	-3.3765	20.7610	0.0040
	KM1DEM	1.0	280.0	100.1072	53.0414	0.0145	52.9847	0.1367
	KM1ASPCT	1.0	10.0	4.6438	3.0251	0.6162	65.1444	0.0078
	PSNRAW	21.0	702.0	516.1559	49.2145	-0.1232	9.5348	0.1261

Basic Statistics - 1km Resolution TEO System

Reg Variable	Low	High	Mean	StdDev	Skewness	Cv	StdMean
1 LAT	54.7	56.8	55.5221	0.5462	0.4706	0.9838	0.0031
LONG	-89.8	-82.2	-86.4161	1.8694	0.4067	-2.1633	0.0105
ANNPM	4889.0	5670.0	5230.8900	170.9686	0.4124	3.2684	0.9623
JANPM	17.0	23.0	20.3217	1.1842	0.3258	5.8271	0.0067
JULYPM	74.0	87.0	81.3284	2.5952	-0.3084	3.1910	0.0146
ANNMAX	2725.0	2748.0	2739.1300	5.5603	-0.5168	0.2030	0.0313
ANNMIN	2631.0	2643.0	2637.3830	2.3263	-0.7293	0.0882	0.0131
MAXJULY	2915.0	2932.0	2922.8650	3.4051	0.1390	0.1165	0.0192
MINJAN	2413.0	2423.0	2419.5310	1.9870	-0.6100	0.0821	0.0112
ANNTEMP	2679.0	2695.0	2688.3130	3.8749	-0.7544	0.1441	0.0218
JANTEMP	2467.0	2484.0	2476.7210	4.0676	-0.4720	0.1642	0.0229
JULYTEMP	2862.0	2881.0	2873.5830	3.5525	-0.8576	0.1236	0.0200
ANNDD5	699.0	875.0	782.5960	32.5663	-0.0645	4.1613	0.1833
GROWLEN	138.0	150.0	144.3969	2.3691	-0.5227	1.6407	0.0133
DEMBOUND	1.0	13.0	6.6744	3.3378	-0.2722	50.0107	0.0200
GEOL1KM	0.0	8.0	7.9251	0.5319	-11.7640	6.7116	0.0030
KM1DEM	1.0	124.0	38.4086	27.0200	0.4121	70.3488	0.1619
KM1ASPCT	1.0	10.0	4.1321	3.0945	0.8417	74.8888	0.0189
PSNRAW	18.0	501.0	392.4738	53.7612	-3.1194	13.6980	0.3079
2 LAT	51.2	56.4	54.2416	1.0814	-0.7738	1.9937	0.0032
LONG	-91.8	-80.7	-86.5102	2.5420	0.0424	-2.9384	0.0074
ANNPM	5009.0	6800.0	5777.3520	305.2663	0.4782	5.2838	0.8897
JANPM	18.0	40.0	25.3097	3.3790	1.6186	13.3506	0.0099
JULYPM	78.0	99.0	87.6611	4.0050	0.5010	4.5688	0.0117
ANNMAX	2726.0	2785.0	2751.8520	11.3680	0.6559	0.4138	0.0332
ANNMIN	2630.0	2661.0	2643.6800	5.7247	0.2964	0.2165	0.0167
MAXJULY	2918.0	2962.0	2935.6730	8.6660	0.5763	0.2952	0.0253
MINJAN	2411.0	2446.0	2423.4080	5.7461	0.8364	0.2371	0.0168
ANNTEMP	2680.0	2723.0	2697.8190	8.4417	0.5601	0.3129	0.0246
JANTEMP	2466.0	2514.0	2484.2120	9.0432	0.9567	0.3640	0.0264
JULYTEMP	2866.0	2898.0	2883.1510	6.3275	-0.2915	0.2195	0.0184
ANNDD5	739.0	1167.0	904.4735	86.3960	0.2981	9.5521	0.2519
GROWLEN	140.0	165.0	151.4539	4.9586	0.2366	3.2740	0.0145
DEMBOUND	1.0	13.0	6.0687	3.3986	-0.0580	56.0025	0.0099
GEOL1KM	0.0	8.0	7.7238	1.2095	-4.5724	15.6601	0.0035
KM1DEM	1.0	194.0	100.3403	30.5790	-0.7164	30.4753	0.0891
KM1ASPCT	1.0	10.0	5.1377	3.1168	0.3535	60.6640	0.0091
PSNRAW	309.0	578.0	431.1040	37.7388	-0.0336	8.7540	0.1100
3 LAT	52.0	54.9	53.3268	0.8730	0.2031	1.2620	0.0021
LONG	-94.7	-87.0	-90.4708	1.8162	-0.0097	-2.0075	0.0057
ANNPM	5739.0	7449.0	6576.9870	352.4814	0.0742	5.3583	1.1114
JANPM	24.0	39.0	31.5590	2.8684	-0.1265	9.0890	0.0090
JULYPM	84.0	103.0	93.3851	4.2345	0.0865	4.5237	0.0133
ANNMAX	2747.0	2788.0	2762.5940	7.7938	-0.0111	0.2821	0.0246
ANNMIN	2643.0	2670.0	2653.3100	5.8909	0.6203	0.2220	0.0186
MAXJULY	2935.0	2963.0	2948.9830	6.7031	0.0010	0.2273	0.0211
MINJAN	2422.0	2451.0	2431.7980	5.8428	0.7864	0.2403	0.0184
ANNTEMP	2685.0	2725.0	2708.0050	6.8883	0.2106	0.2474	0.0211
JANTEMP	2480.0	2511.0	2492.0330	6.9892	0.3281	0.2681	0.0211
JULYTEMP	2880.0	2906.0	2896.0610	5.3451	0.2752	0.1844	0.0169
ANNDD5	913.0	1298.0	1088.7950	88.9410	0.3598	7.9851	0.2741
GROWLEN	152.0	170.0	160.1371	4.2305	0.3941	2.6418	0.0133
DEMBOUND	1.0	13.0	7.1883	3.1979	-0.4915	44.4875	0.0102
GEOL1KM	0.0	8.0	2.8956	2.0314	1.2026	71.1369	0.0064
KM1DEM	76.0	422.0	247.1292	61.8554	0.0799	25.0296	0.1974
KM1ASPCT	1.0	10.0	4.6301	2.9089	0.4757	62.8256	0.0094
PSNRAW	213.0	627.0	474.9403	35.5111	-1.0755	7.4770	0.1120
4 LAT	53.4	55.0	54.0162	0.4421	0.4647	0.8184	0.0043
LONG	-93.8	-91.6	-92.6907	0.4936	0.1726	-0.5327	0.0048
ANNPM	5699.0	6660.0	6186.8360	187.1514	-0.4679	3.0250	1.8383
JANPM	25.0	33.0	29.9424	1.6724	-0.4438	5.5853	0.0165
JULYPM	83.0	92.0	87.5907	1.6989	-0.4648	1.9395	0.0167
ANNMAX	2748.0	2769.0	2759.9880	5.3162	-0.5286	0.1926	0.0524
ANNMIN	2645.0	2660.0	2652.7230	3.9891	-0.3281	0.1504	0.0394
MAXJULY	2940.0	2956.0	2948.8740	4.2461	-0.6016	0.1440	0.0419
MINJAN	2422.0	2436.0	2430.0360	2.7707	-0.1997	0.1140	0.0273
ANNTEMP	2697.0	2715.0	2706.4310	4.5902	-0.4648	0.1696	0.0453
JANTEMP	2479.0	2496.0	2488.6220	3.7598	-0.2459	0.1511	0.0371
JULYTEMP	2890.0	2905.0	2898.6290	3.8199	-0.5016	0.1318	0.0377
ANNDD5	961.0	1195.0	1069.4500	60.4270	-0.4548	5.5466	0.5962
GROWLEN	153.0	165.0	160.2192	3.1395	-0.5316	1.9595	0.0310
DEMBOUND	1.0	13.0	7.6885	2.9793	-0.6832	38.7495	0.0293
GEOL1KM	0.0	8.0	2.4094	1.7073	1.6167	70.8590	0.0167
KM1DEM	107.0	359.0	236.5586	43.7527	-0.5767	18.4955	0.4297
KM1ASPCT	1.0	10.0	4.6264	2.8683	0.3037	61.9997	0.0285
PSNRAW	357.0	555.0	477.5482	27.9436	-0.2917	5.8515	0.2740
5 LAT	49.8	54.7	51.6362	1.0427	0.4815	2.0193	0.0027
LONG	-87.3	-79.5	-83.5971	1.7915	0.0504	-2.1430	0.0046
ANNPM	5039.0	8249.0	6457.2820	652.1185	-0.0285	10.0990	1.6706
JANPM	18.0	57.0	36.3681	8.3251	0.0645	22.8913	0.0213
JULYPM	81.0	105.0	91.9419	4.9751	0.3128	5.4111	0.0127
ANNMAX	2747.0	2799.0	2779.4940	10.2420	-0.5477	0.3685	0.0262
ANNMIN	2638.0	2676.0	2657.5080	7.1951	-0.0213	0.2707	0.0184
MAXJULY	2921.0	2972.0	2956.7430	9.5184	-0.8647	0.3219	0.0244
MINJAN	2420.0	2473.0	2440.8680	11.8932	0.2461	0.4873	0.0305
ANNTEMP	2692.0	2736.0	2718.4900	8.5395	-0.3448	0.3141	0.0219
JANTEMP	2482.0	2536.0	2509.7770	12.8132	-0.0115	0.5105	0.0328
JULYTEMP	2866.0	2907.0	2894.5430	8.0473	-0.9067	0.2780	0.0206
ANNDD5	744.0	1321.0	1114.0890	112.1001	-0.6236	10.0620	0.2872
GROWLEN	145.0	173.0	163.1418	5.5913	-0.6942	3.4273	0.0143
DEMBOUND	1.0	13.0	6.5916	3.2217	-0.2630	48.8750	0.0083
GEOL1KM	0.0	8.0	7.2069	1.9898	-2.2653	27.6103	0.0051
KM1DEM	1.0	287.0	103.0520	60.2970	0.0285	58.5113	0.1562
KM1ASPCT	1.0	10.0	4.5386	2.9484	0.6844	64.9632	0.0077
PSNRAW	21.0	714.0	526.1325	51.6401	-0.2241	9.8150	0.1326
6 LAT	49.0	53.0	50.8842	0.9232	0.0245	1.8144	0.0026
LONG	-92.5	-85.0	-89.1178	1.7481	0.1175	-1.9615	0.0049
ANNPM	6339.0	9440.0	7382.1960	319.3385	-0.4891	4.3258	0.8881
JANPM	26.0	67.0	40.0700	4.6454	1.3288	11.5933	0.0129
JULYPM	78.0	107.0	94.9858	6.6191	-0.3725	6.9642	0.0184
ANNMAX	2766.0	2803.0	2784.3690	8.5366	-0.1783	0.3066	0.0237
ANNMIN	2643.0	2694.0	2680.2910	10.8529	1.0681	0.4080	0.0302
MAXJULY	2932.0	2977.0	2963.3240	7.0366	-0.7025	0.2375	0.0196
MINJAN	2420.0	2495.0	2441.1150	14.5691	0.9818	0.5968	0.0405
ANNTEMP	2707.0	2747.0	2722.3430	8.7567	0.7069	0.3217	0.0244
JANTEMP	2491.0	2563.0	2511.6750	13.6208	0.8001	0.5423	0.0379
JULYTEMP	2880.0	2924.0	2903.5940	7.9598	0.5614	0.2741	0.0221
ANNDD5	1022.0	1563.0	1213.6330	107.1038	1.2815	8.8251	0.2979
GROWLEN	159.0	183.0	166.9194	4.7065	0.9894	2.8196	0.0131
DEMBOUND	1.0	13.0	7.4481	3.0160	-0.6742	40.5043	0.0084
GEOL1KM	0.0	8.0	2.8459	1.8474	1.1843	65.0278	0.0051
KM1DEM	190.0	518.0	344.6735	52.9871	-0.1341	15.3598	0.1475
KM1ASPCT	1.0	10.0	4.7313	2.7051	0.3821	57.1742	0.0076
PSNRAW	306.0	729.0	535.7491	53.4858	0.6811	11.8499	0.1763

Reg	Variable	Low	High	Mean	StdDev	Skewness	Cv	StdMean
7	LAT	49.5	53.1	51.1842	0.8618	0.1201	1.6832	0.0031
	LONG	-95.2	-91.5	-93.6265	0.9385	0.1786	-1.0024	0.0034
	ANNPM	5570.0	7190.0	6517.6130	331.6289	-0.2084	5.0882	1.2023
	JANPM	25.0	39.0	32.4173	2.6739	-0.3027	8.2485	0.0987
	JULYPM	75.0	97.0	86.8067	5.0330	-0.1955	5.8114	0.0182
	ANNMAX	2774.0	2808.0	2790.1450	8.3700	-0.0142	0.3000	0.0303
	ANNMIN	2663.0	2697.0	2678.6790	8.7198	0.1373	0.3254	0.0316
	MAXJULY	2960.0	2983.0	2970.3650	5.0374	0.0846	0.1698	0.0215
	MINJAN	2435.0	2487.0	2461.0560	12.9721	0.0880	0.5271	0.0470
	ANNTEMP	2717.0	2750.0	2734.3670	8.4388	-0.0011	0.3086	0.0306
	JANTEMP	2498.0	2546.0	2522.1960	12.0615	0.0672	0.4782	0.0437
	JULYTEMP	2906.0	2927.0	2915.5560	4.8884	0.2461	0.1677	0.0177
	ANNDDS	1221.0	1637.0	1416.5270	88.4775	0.1919	7.0226	0.3806
	GROWLEN	166.0	186.0	175.9958	4.9278	0.0588	2.7998	0.0179
	DEMBOUND	1.0	13.0	7.7030	2.8832	-0.6767	37.1686	0.0106
	GEOL1KM	0.0	8.0	2.1739	1.8452	1.4026	84.8812	0.0067
	KM1DEM	272.0	480.0	385.5074	31.7058	-0.0430	8.8745	0.1167
	KM1ASPCT	1.0	10.0	5.0267	2.5933	0.0428	51.5806	0.0097
	PSNRAW	261.0	615.0	482.0375	53.3901	-0.8861	11.0759	0.1936
8	LAT	47.7	51.1	49.3697	0.6385	0.2915	1.2933	0.0021
	LONG	-87.3	-79.5	-82.8635	1.9046	-0.1721	-2.4063	0.0064
	ANNPM	6600.0	9760.0	8007.0870	543.2865	-0.7281	6.7851	1.7580
	JANPM	37.0	75.0	54.7716	6.7518	-0.4532	12.3272	0.0218
	JULYPM	78.0	108.0	91.7847	6.8458	0.2698	7.4584	0.0222
	ANNMAX	2776.0	2808.0	2795.2860	5.8078	-0.6455	0.2078	0.0188
	ANNMIN	2648.0	2682.0	2669.3530	7.4544	-0.3961	0.2793	0.0241
	MAXJULY	2927.0	2980.0	2965.5910	6.5723	-1.0730	0.2216	0.0213
	MINJAN	2427.0	2506.0	2464.4380	12.5571	-0.2439	0.5095	0.0406
	ANNTEMP	2712.0	2748.0	2732.4180	6.5417	-0.6308	0.2394	0.0212
	JANTEMP	2504.0	2571.0	2535.8650	11.3089	-0.1304	0.4460	0.0366
	JULYTEMP	2878.0	2914.0	2900.2700	5.7275	-0.5158	0.1975	0.0186
	ANNDDS	1004.0	1431.0	1244.4170	74.2696	-0.3595	5.9682	0.2403
	GROWLEN	161.0	178.0	170.7463	2.9007	-0.6398	1.6990	0.0094
	DEMBOUND	1.0	13.0	7.5148	3.0139	-0.6332	40.1066	0.0097
	GEOL1KM	0.0	8.0	3.4631	1.9760	0.5620	57.0600	0.0064
	KM1DEM	147.0	497.0	275.3749	51.1645	0.7325	18.5800	0.1653
	KM1ASPCT	1.0	10.0	4.7854	2.8081	0.3026	58.6804	0.0091
	PSNRAW	402.0	804.0	646.9905	68.4594	-0.4398	10.5812	0.2208
9	LAT	47.7	49.3	48.5496	0.3628	0.0991	0.7885	0.0020
	LONG	-88.9	-83.7	-85.9123	1.3363	-0.6275	-1.5554	0.0060
	ANNPM	7408.0	10439.0	8822.4850	762.4512	0.0111	8.6421	5.1868
	JANPM	43.0	85.0	65.9457	11.9383	-0.4460	18.1037	0.0812
	JULYPM	71.0	93.0	85.8972	3.9989	-1.0414	4.6094	0.0272
	ANNMAX	2786.0	2808.0	2796.9390	5.5233	0.1473	0.1295	0.0246
	ANNMIN	2650.0	2702.0	2680.9570	8.8516	-0.0310	0.2556	0.0466
	MAXJULY	2918.0	2972.0	2945.9080	11.0437	0.1945	0.3853	0.0792
	MINJAN	2442.0	2526.0	2487.3760	13.6472	-0.2990	0.5487	0.0828
	ANNTEMP	2723.0	2756.0	2739.0000	4.3463	-0.1477	0.1588	0.0296
	JANTEMP	2522.0	2588.0	2558.8710	10.7110	-0.1980	0.4189	0.0729
	JULYTEMP	2873.0	2906.0	2888.0190	6.9398	0.4452	0.2403	0.0472
	ANNDDS	986.0	1315.0	1159.3780	62.8043	0.1561	5.4171	0.4272
	GROWLEN	165.0	184.0	173.6500	2.6000	0.1631	1.4973	0.0177
	DEMBOUND	1.0	13.0	8.9157	2.1998	-0.8405	24.6731	0.0159
	GEOL1KM	0.0	8.0	2.5074	1.4478	1.7043	57.7421	0.0098
	KM1DEM	50.0	548.0	353.9539	69.1835	-0.2985	19.5615	0.4706
	KM1ASPCT	1.0	10.0	4.8982	2.2053	-0.0846	45.0219	0.0151
	PSNRAW	495.0	777.0	668.6742	45.8660	-0.3679	6.8628	0.3199
10	LAT	48.5	50.5	49.5157	0.4442	0.0095	0.8970	0.0025
	LONG	-92.2	-87.8	-89.3747	0.9253	-0.6692	-1.0353	0.0052
	ANNPM	6188.0	8358.0	7511.5060	356.2579	-0.9865	4.7695	2.0197
	JANPM	24.0	51.0	41.4988	4.6236	-1.1765	11.1422	0.0261
	JULYPM	83.0	98.0	92.3948	3.4416	-0.3814	3.7249	0.0194
	ANNMAX	2784.0	2811.0	2798.2270	3.4757	-0.4801	0.1243	0.0196
	ANNMIN	2645.0	2692.0	2685.3970	9.2506	0.2943	0.3471	0.0522
	MAXJULY	2958.0	2977.0	2970.1770	3.0793	-0.6825	0.1037	0.0174
	MINJAN	2420.0	2505.0	2449.9880	13.8980	0.3455	0.5673	0.0784
	ANNTEMP	2713.0	2752.0	2730.8850	6.2274	-0.0636	0.2280	0.0351
	JANTEMP	2500.0	2570.0	2525.0670	10.4250	0.4706	0.4129	0.0588
	JULYTEMP	2892.0	2923.0	2904.2140	5.7586	1.2478	0.1983	0.0325
	ANNDDS	1087.0	1556.0	1245.3490	81.8306	1.3790	6.5709	0.4613
	GROWLEN	162.0	183.0	169.5343	3.4095	1.0757	2.0111	0.0192
	DEMBOUND	1.0	13.0	8.3392	2.5735	-0.9881	30.8608	0.0157
	GEOL1KM	0.0	7.0	2.9076	2.0541	0.4832	70.6466	0.0115
	KM1DEM	204.0	548.0	398.2834	75.1594	-0.5130	18.8686	0.4588
	KM1ASPCT	1.0	10.0	4.6166	2.4091	0.2833	52.1814	0.0150
	PSNRAW	18.0	720.0	571.6868	90.6334	-1.8487	15.8536	0.5195
11	LAT	48.0	49.4	48.8833	0.3150	0.3624	0.6483	0.0020
	LONG	-92.0	-88.1	-90.5614	0.8494	0.5977	-0.9380	0.0055
	ANNPM	6469.0	8350.0	7680.8820	304.8998	-0.9191	3.9646	1.9645
	JANPM	27.0	51.0	42.0422	5.2014	-0.6367	12.3719	0.0335
	JULYPM	80.0	102.0	95.9454	3.8611	-2.1776	4.0243	0.0249
	ANNMAX	2798.0	2816.0	2806.7940	4.2107	0.2914	0.1500	0.0271
	ANNMIN	2661.0	2697.0	2679.0570	8.5494	-0.1560	0.2444	0.0422
	MAXJULY	2956.0	2982.0	2972.7270	4.2956	-0.7565	0.1445	0.0277
	MINJAN	2452.0	2512.0	2474.0160	11.5086	0.0169	0.4652	0.0741
	ANNTEMP	2730.0	2757.0	2742.9330	4.8717	0.0343	0.1776	0.0314
	JANTEMP	2527.0	2577.0	2545.0550	9.9748	0.7743	0.3919	0.0642
	JULYTEMP	2895.0	2921.0	2906.6790	5.5898	0.1438	0.1923	0.0360
	ANNDDS	1173.0	1573.0	1358.8610	84.3743	0.1921	6.2101	0.5432
	GROWLEN	167.0	186.0	176.9097	3.7807	-0.0116	2.1258	0.0242
	DEMBOUND	1.0	13.0	7.9445	2.7239	-0.8955	34.2868	0.0176
	GEOL1KM	0.0	7.0	3.5111	2.1570	0.7184	61.4333	0.0139
	KM1DEM	184.0	610.0	421.4061	72.6207	-1.5418	17.2329	0.4683
	KM1ASPCT	1.0	10.0	4.9791	2.4481	0.1108	49.1267	0.0160
	PSNRAW	69.0	714.0	583.2313	82.5427	-0.4380	10.7235	0.4115
12	LAT	48.2	50.1	49.1857	0.3948	0.1460	0.8027	0.0021
	LONG	-96.2	-91.6	-93.3794	0.9167	0.0963	-0.9817	0.0049
	ANNPM	5749.0	7919.0	6771.3810	420.6133	-0.1777	6.2117	2.2763
	JANPM	23.0	46.0	31.5150	3.7278	1.1119	11.8285	0.0202
	JULYPM	80.0	98.0	90.4981	4.2191	-0.5477	4.6621	0.0228
	ANNMAX	2798.0	2819.0	2807.9560	3.9758	-0.1624	0.1416	0.0215
	ANNMIN	2640.0	2700.0	2693.5100	3.9864	-0.9238	0.1483	0.0216
	MAXJULY	2975.0	2986.0	2980.7030	2.2371	-0.2430	0.0751	0.0121
	MINJAN	2462.0	2492.0	2482.5820	5.9720	-0.9510	0.2406	0.0323
	ANNTEMP	2741.0	2757.0	2750.6800	3.3232	-0.3499	0.1208	0.0180
	JANTEMP	2529.0	2558.0	2545.4410	5.1102	-0.4373	0.2008	0.0277
	JULYTEMP	2913.0	2929.0	2922.8880	2.7586	-1.1168	0.0944	0.0149
	ANNDDS	1432.0	1687.0	1589.1160	50.1329	-0.6418	3.1350	0.2713
	GROWLEN	178.0	190.0	184.8314	2.2704	-0.5251	1.2284	0.0123
	DEMBOUND	1.0	13.0	7.2237	2.9574	-0.8109	40.9402	0.0161
	GEOL1KM	0.0	7.0	2.0584	1.3729	1.6836	66.6964	0.0074
	KM1DEM	320.0	489.0	370.4633	32.7729	0.7965	8.8464	0.1789
	KM1ASPCT	1.0	10.0	5.2351	2.5763	0.0091	49.2119	0.0143
	PSNRAW	57.0	651.0	532.5479	61.3291	-1.7718	11.5154	0.3347

Reg Variable	Low	High	Mean	StdDev	Skewness	Cv	StdMean
13 LAT	42.0	51.0	47.4201	0.3230	0.2171	0.6812	0.0022
LONG	-83.0	-78.7	-81.8418	1.1181	-0.2461	-1.3662	0.0064
ANNPRJ	724.0	1144.0	874.0968	69.8235	1.1783	7.9894	0.4564
JANPRJ	0.0	10.0	3.0308	1.1937	0.1277	39.3935	0.0725
JULYPRJ	0.0	10.0	3.0880	0.7229	-0.2448	23.4169	0.0268
ANNMAX	278.0	353.0	311.4410	7.0279	0.4330	2.2570	0.0239
ANNMIN	26.0	273.0	200.9950	10.9810	-1.4555	5.4660	0.0346
MAXJULY	26.0	281.0	214.9280	9.6897	0.5133	4.5060	0.0300
MINJAN	25.0	257.0	200.1192	10.4721	0.3436	5.2318	0.0663
ANNTEMP	27.0	278.0	215.1630	9.8864	-0.4041	4.5955	0.0278
JANTEMP	25.0	262.0	208.5780	10.4716	-0.6488	5.0210	0.0461
JULYTEMP	28.0	283.0	221.2810	9.1426	0.1598	4.1324	0.0286
ANNDOS	114.0	174.0	143.7240	10.1076	0.7469	7.0350	0.5143
GROWLEN	1.0	185.0	161.1287	2.3109	-0.7982	1.4342	0.0115
DEMSOURC	0.0	1.0	0.2975	0.4563	1.0882	153.3613	0.0112
GEOLHM	0.0	1.0	0.2149	0.4108	1.4115	191.1284	0.0107
KMTDEM	1.0	8.0	3.6972	2.3687	-0.1515	64.0611	0.4136
KMTASPCT	1.0	10.0	4.6882	2.3687	-0.1515	50.5331	0.4136
PSNRAW	1.0	849.0	743.3488	45.6167	-3.4402	6.1369	0.2712
14 LAT	44.0	457	45.6248	0.5462	-0.2171	1.1968	0.0034
LONG	-84.5	-78.8	-79.3032	1.5733	-0.8125	-1.9838	0.0083
ANNPRJ	788.0	1139.0	952.6970	67.2388	0.2979	7.0592	3.2620
JANPRJ	4.0	110.0	72.6681	15.3005	0.3467	21.0560	0.0410
JULYPRJ	0.0	10.0	3.5533	0.8767	0.0282	24.6753	0.0352
ANNMAX	284.0	364.0	320.1580	4.6358	0.2975	1.4480	0.0363
ANNMIN	27.0	274.0	216.0660	8.6173	0.3966	3.9900	0.0558
MAXJULY	28.0	289.0	231.5830	4.6753	-0.7723	2.0190	0.0331
MINJAN	27.0	281.0	224.3610	14.8045	0.5832	6.5978	0.1824
ANNTEMP	27.0	279.0	222.9720	8.3947	0.3964	3.7648	0.0796
JANTEMP	25.0	268.0	212.6950	11.7944	0.4858	5.5460	0.0451
JULYTEMP	28.0	287.0	230.1588	4.7044	0.1255	2.0439	0.0593
ANNDOS	143.0	197.0	169.1456	10.5438	0.4279	6.2344	0.0368
GROWLEN	1.0	185.0	158.1568	7.1901	-0.1231	4.5460	0.8713
DEMSOURC	0.0	1.0	0.8784	2.4886	-0.8264	283.2139	0.0359
GEOLHM	0.0	1.0	0.5305	1.8541	1.6888	349.4722	0.0193
KMTDEM	1.0	5.0	2.6513	83.4229	0.3637	3.1468	0.0122
KMTASPCT	0.0	10.0	4.7445	3.3433	0.0762	70.4660	0.2602
PSNRAW	1.0	870.0	770.3778	44.7778	-1.8742	5.8125	0.1793
15 LAT	44.4	45.9	45.1128	0.3143	-0.1725	0.6966	0.0021
LONG	-77.3	-75.9	-76.9888	0.7710	0.2878	-1.0020	0.0048
ANNPRJ	778.0	950.0	840.9685	19.9847	-0.4758	2.3768	0.1478
JANPRJ	4.0	70.0	27.4286	4.8016	-0.4864	17.5107	0.0298
JULYPRJ	0.0	8.0	2.9388	0.8812	-0.0975	29.9852	0.0141
ANNMAX	288.0	332.0	308.1470	3.2398	0.2459	1.0514	0.0315
ANNMIN	27.0	274.0	204.0780	8.1458	-0.4218	3.9904	0.0201
MAXJULY	28.0	297.0	236.9950	2.0958	-0.0884	0.8842	0.0176
MINJAN	26.0	268.0	197.9650	11.8051	-0.2263	5.9633	0.0702
ANNTEMP	27.0	280.0	214.2770	9.6416	0.3962	4.5000	0.0373
JANTEMP	25.0	267.0	208.1060	4.3436	0.5396	2.0870	0.0602
JULYTEMP	28.0	317.0	240.1960	88.2515	-0.4060	36.7500	0.0588
ANNDOS	174.0	213.0	199.1980	4.1747	-0.3946	2.0965	0.1478
GROWLEN	1.0	185.0	153.6480	7.1552	-0.7073	4.6570	0.0141
DEMSOURC	0.0	1.0	0.2913	0.4572	0.3774	157.0000	0.0201
GEOLHM	0.0	1.0	0.0	0.0	0.0	0.0	0.0176
KMTDEM	1.0	5.0	4.0	1.1539	-1.1539	28.8475	0.0702
KMTASPCT	1.0	10.0	4.6126	2.8343	0.3387	61.4357	0.4091
PSNRAW	516.0	828.0	726.9640	36.4189	-0.7958	5.2202	0.2371

APPENDIX II

Variance Component Analysis Summary

Variance component analysis summary.

Hills

Variable	Between	Within	% Within
ANNDD5	1.058	0.065	5.762
JANPM	0.937	0.172	15.549
ANNMAX	1.065	0.059	5.208
ANNMIN	1.083	0.043	3.784
MAXJULY	0.976	0.138	12.387
MINJAN	1.082	0.043	3.858
ANNTEMP	1.081	0.044	3.934
JANTEMP	1.083	0.043	3.781
JULYTEMP	0.984	0.131	11.717
GROWLEN	1.083	0.043	3.805
ANNPM	0.950	0.160	14.417
JULYPM	0.531	0.531	50.014
DEMBOUND	0.113	0.900	88.846
KM1DEM	0.858	0.242	22.002
PSNRAW	0.978	0.135	12.160
GE_MPS	0.174	0.846	82.920
GE_ED	0.273	0.759	73.564
GE_SIM	0.208	0.817	79.720
GE_CON	0.052	0.954	94.809
VG_MPS	0.076	0.933	92.500
VG_ED	0.566	0.500	46.904
VG_SIM	0.690	0.391	36.158
VG_CON	0.543	0.520	48.915

TEO

Variable	Between	Within	% Within
ANNDD5	1.026	0.077	6.964
JANPM	0.946	0.149	13.585
ANNMAX	1.038	0.065	5.885
ANNMIN	1.043	0.061	5.537
MAXJULY	0.987	0.112	10.195
MINJAN	1.056	0.050	4.526
ANNTEMP	1.046	0.058	5.287
JANTEMP	1.056	0.050	4.495
JULYTEMP	0.964	0.132	12.076
GROWLEN	1.046	0.059	5.332
ANNPM	0.986	0.112	10.224
JULYPM	0.617	0.445	41.899
DEMBOUND	0.130	0.881	87.111
KM1DEM	0.945	0.150	13.662
PSNRAW	0.952	0.143	13.062
GE_MPS	0.200	0.820	80.367
GE_ED	0.294	0.736	71.451
GE_SIM	0.229	0.795	77.654
GE_CON	0.070	0.938	93.085
VG_MPS	0.101	0.910	90.043
VG_ED	0.652	0.413	38.789
VG_SIM	0.753	0.322	29.989
VG_CON	0.653	0.412	38.680

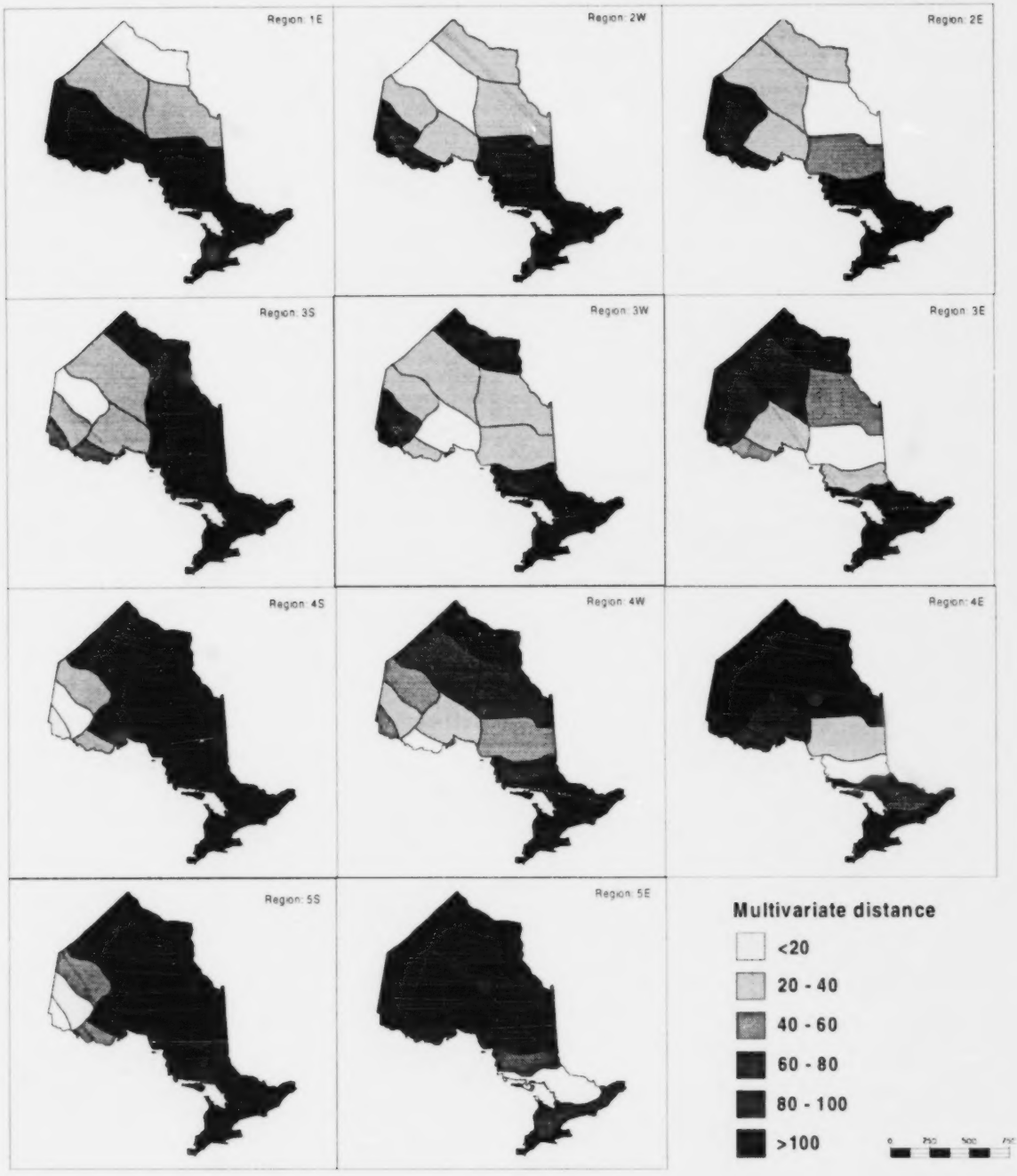
RTEO

Variable	Between	Within	% Within
ANNDD5	1.035	0.073	6.602
JANPM	0.936	0.163	14.833
ANNMAX	1.042	0.067	6.010
ANNMIN	1.054	0.057	5.137
MAXJULY	0.950	0.148	13.497
MINJAN	1.065	0.047	4.269
ANNTEMP	1.055	0.056	5.001
JANTEMP	1.064	0.047	4.272
JULYTEMP	0.965	0.135	12.303
GROWLEN	1.057	0.054	4.820
ANNPM	0.960	0.141	12.775
JULYPM	0.565	0.494	46.638
DEMBOUND	0.135	0.879	86.720
KM1DEM	0.945	0.154	14.045
PSNRAW	0.951	0.150	13.608
GE_MPS	0.173	0.845	82.967
GE_ED	0.276	0.752	73.184
GE_SIM	0.206	0.816	79.826
GE_CON	0.057	0.950	94.315
VG_MPS	0.119	0.895	88.305
VG_ED	0.666	0.404	37.769
VG_SIM	0.775	0.307	28.377
VG_CON	0.665	0.406	37.914

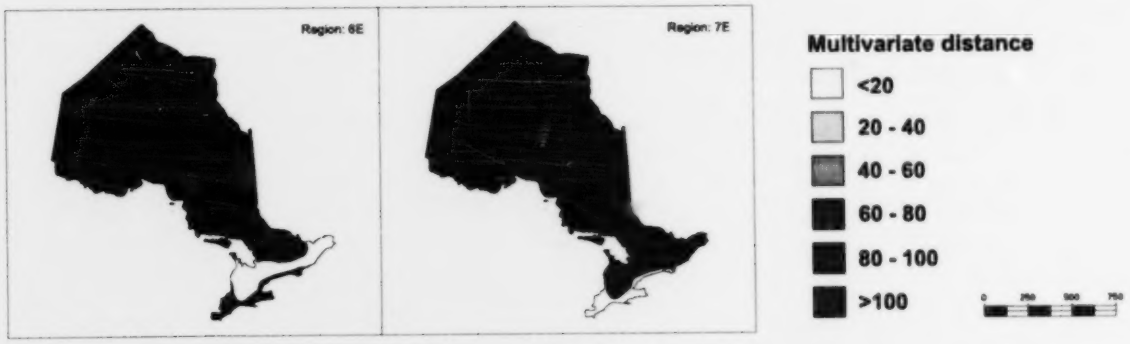
> 50 % within region variance
> 40% within region variance

APPENDIX III

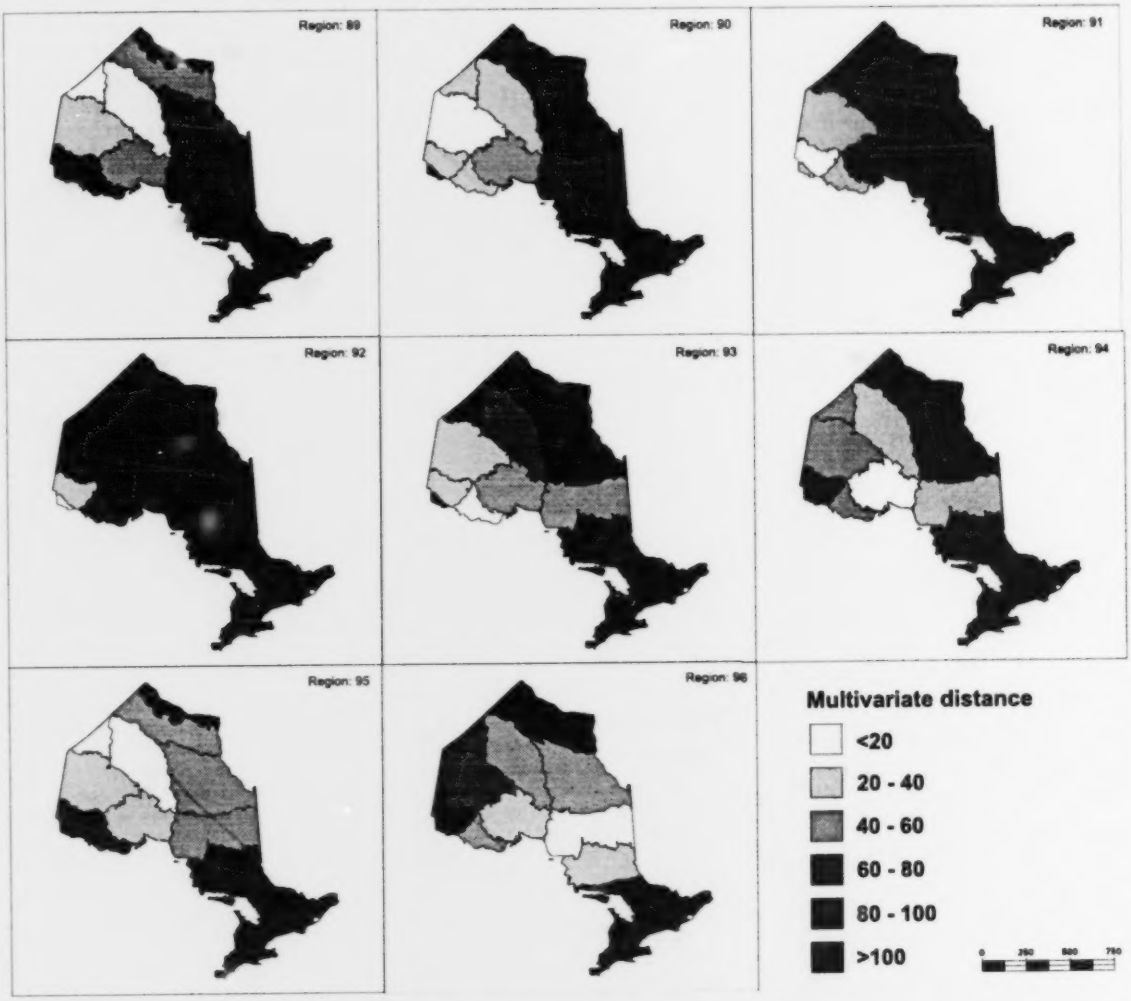
Multivariate Distance Region Maps



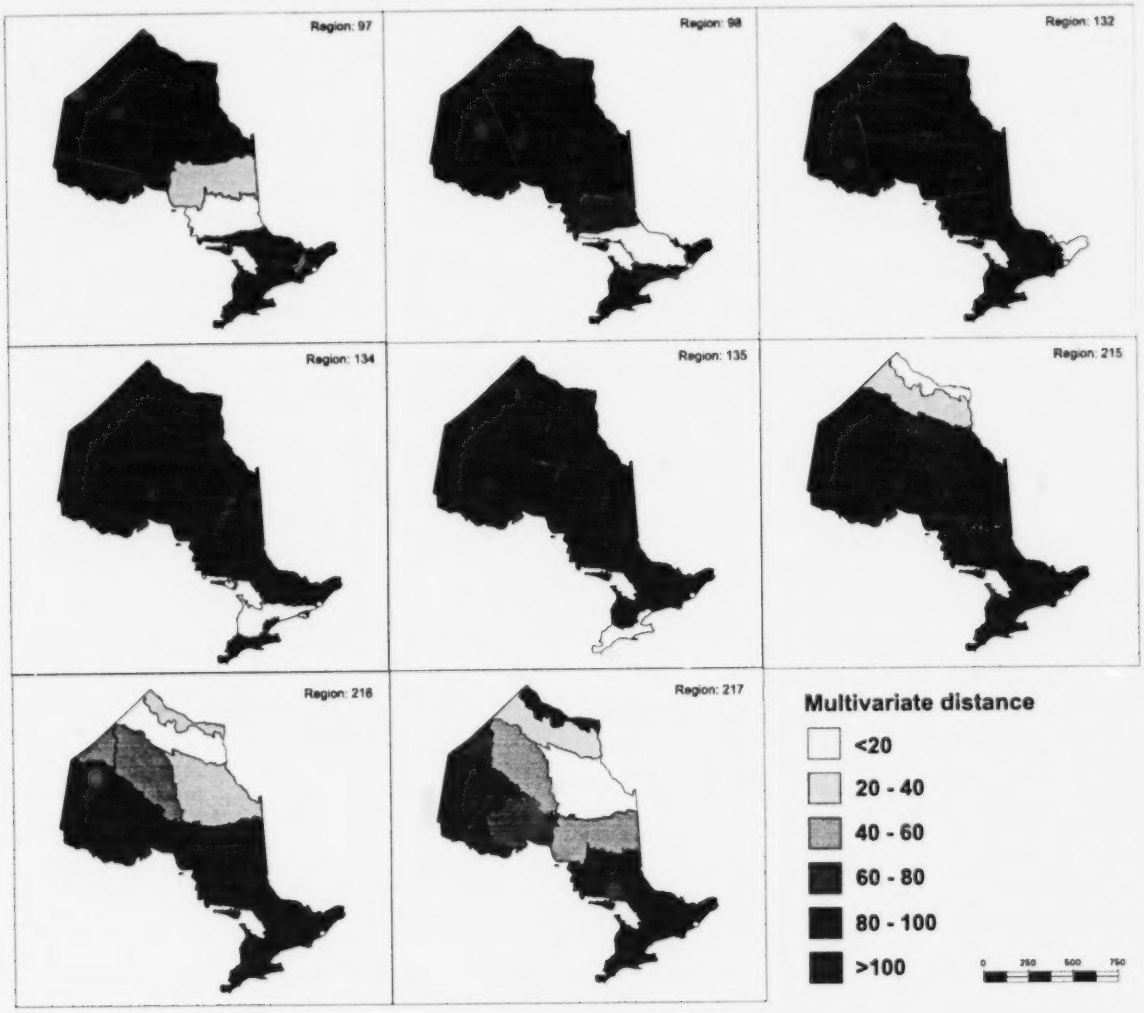
Multivariate distance, Hills System.



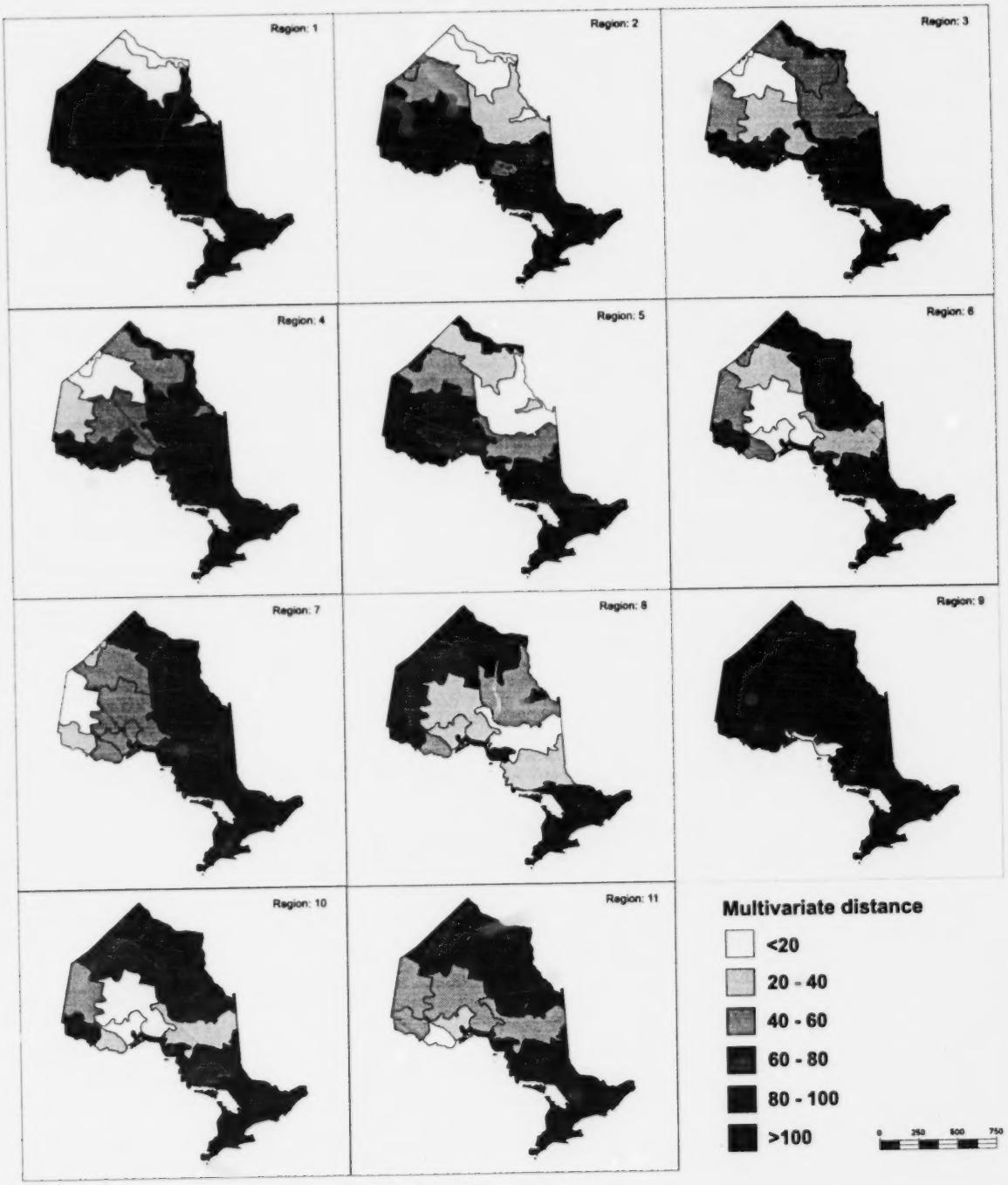
Multivariate distance, Hills System.



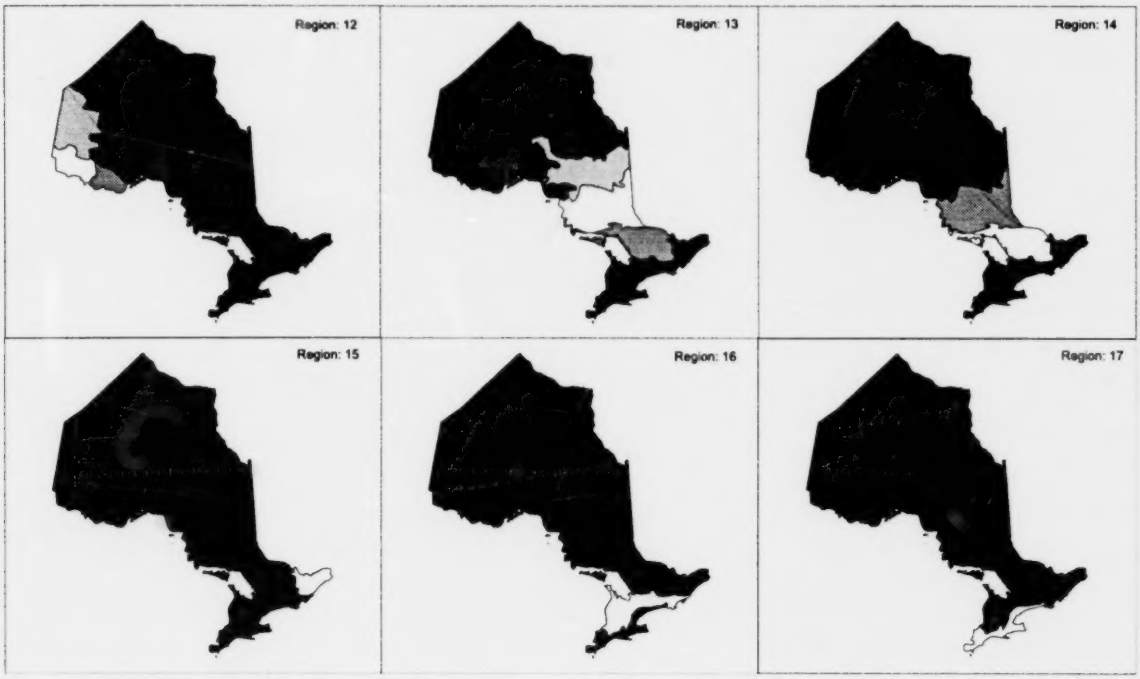
Multivariate distance, RTEO System.



Multivariate distance, RTEO System.



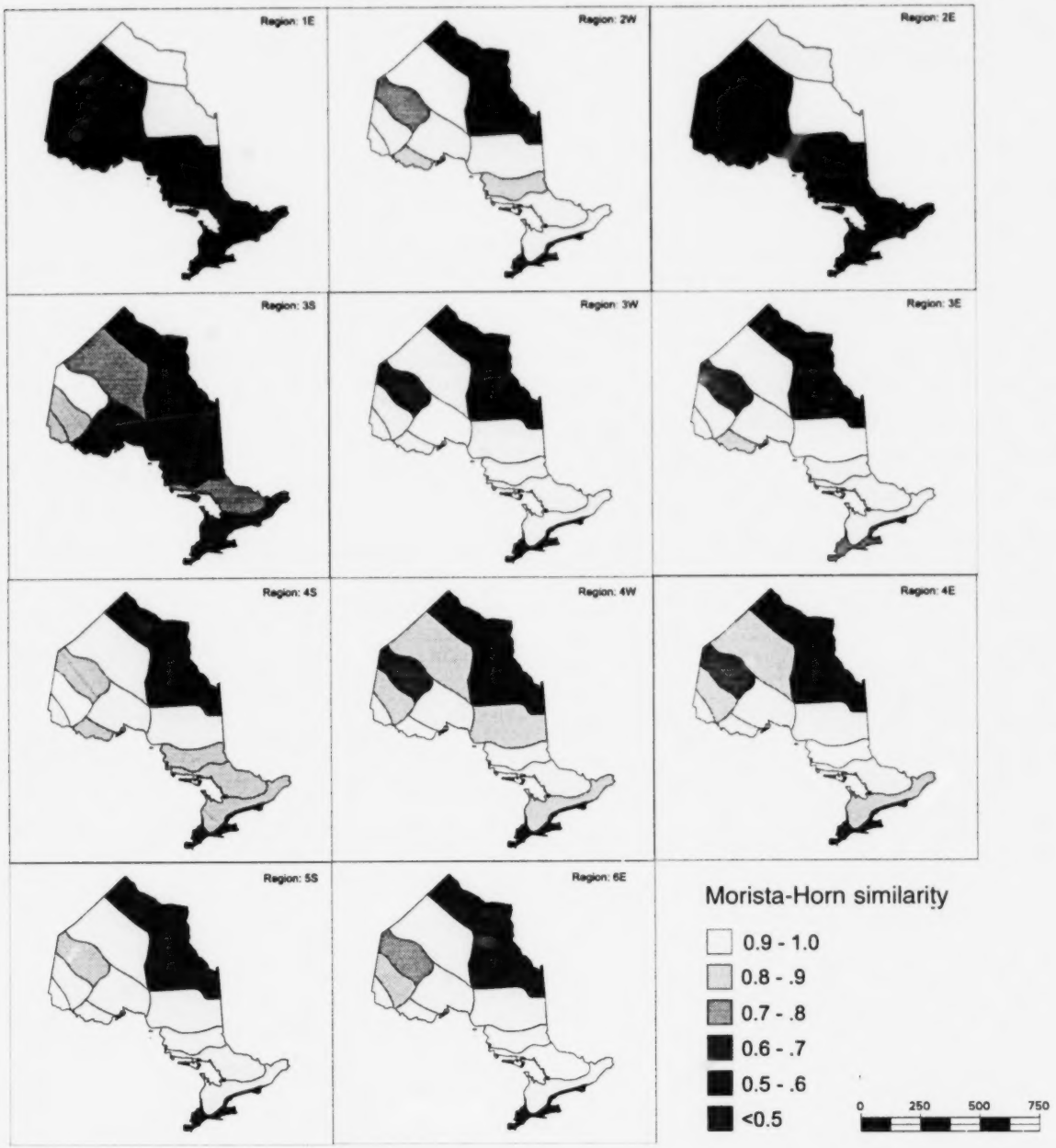
Multivariate distance, TEO System.



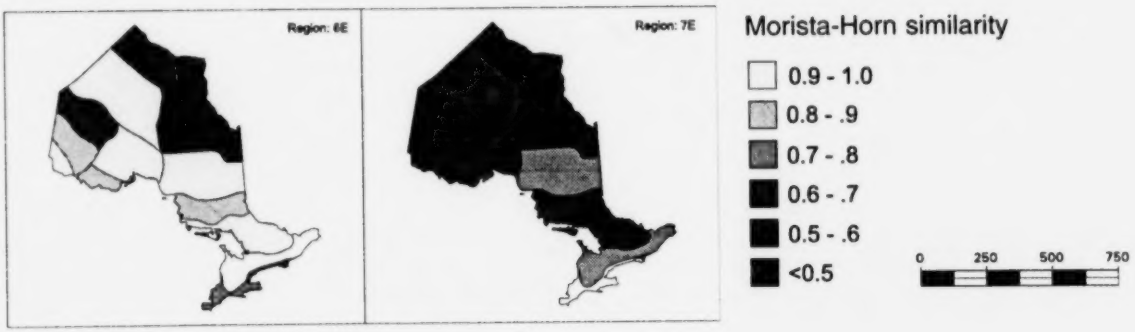
Multivariate distance, TEO System.

APPENDIX IV

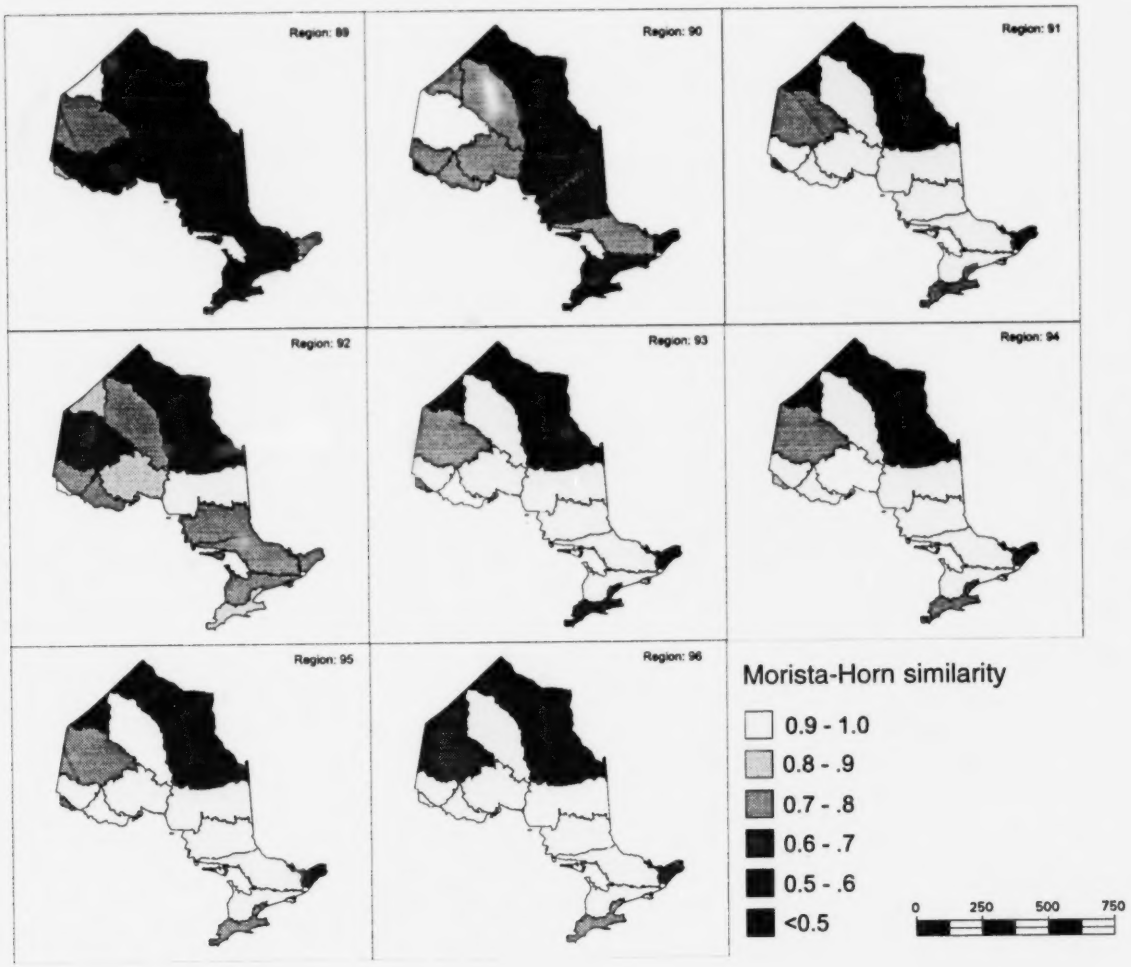
Geologic Similarity Region Maps



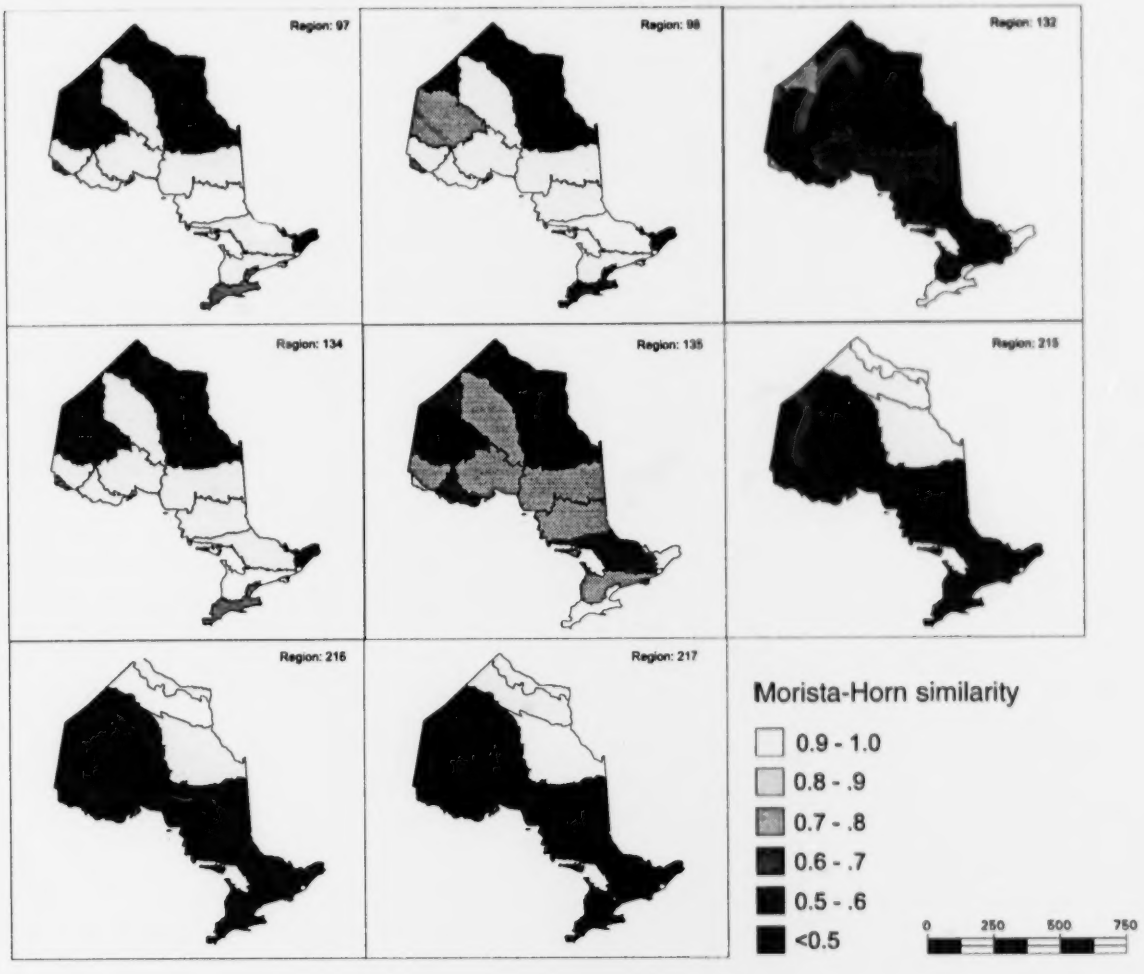
Morista-Horn similarity, Hills System.



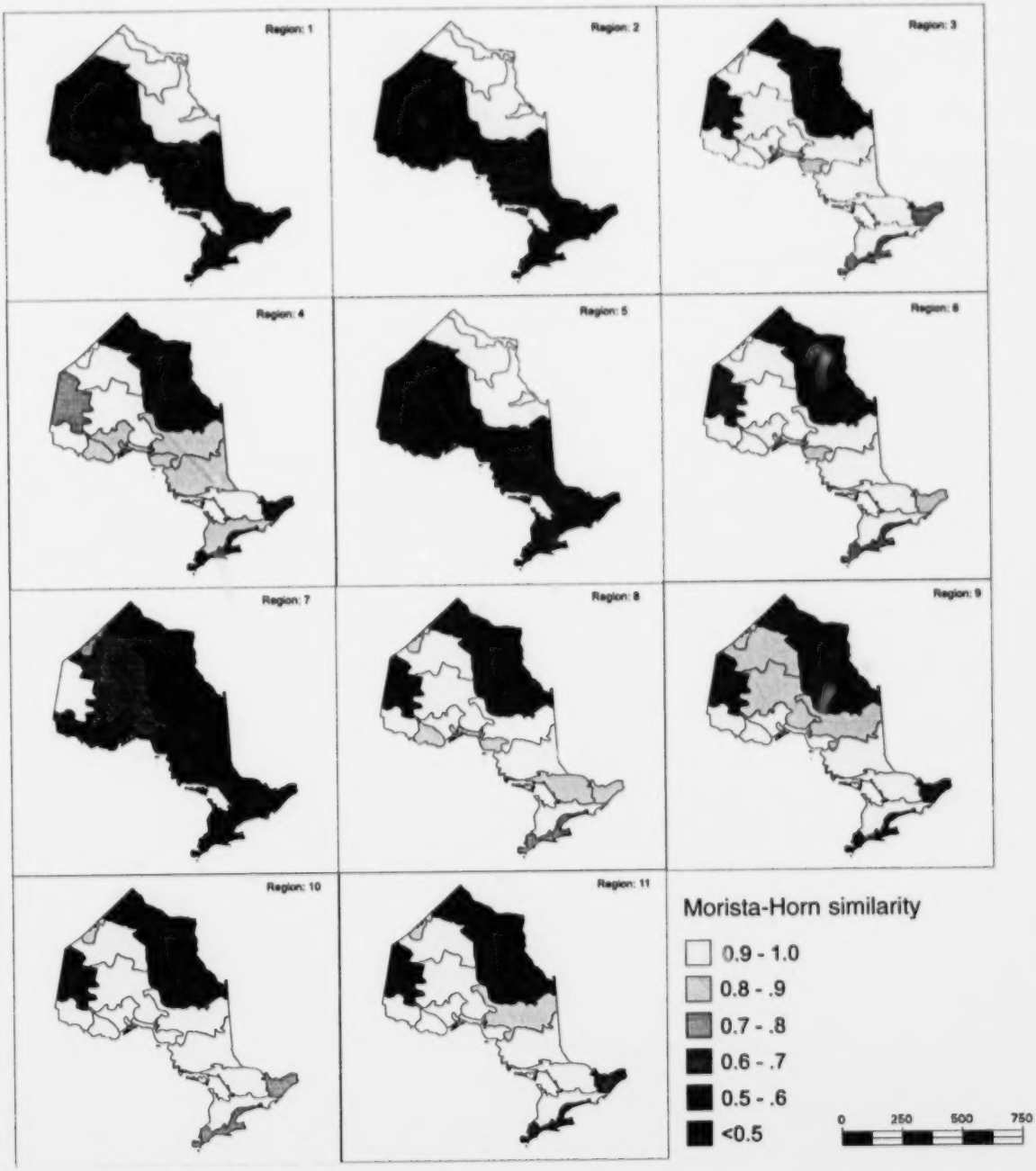
Morista-Horn similarity, Hills System.



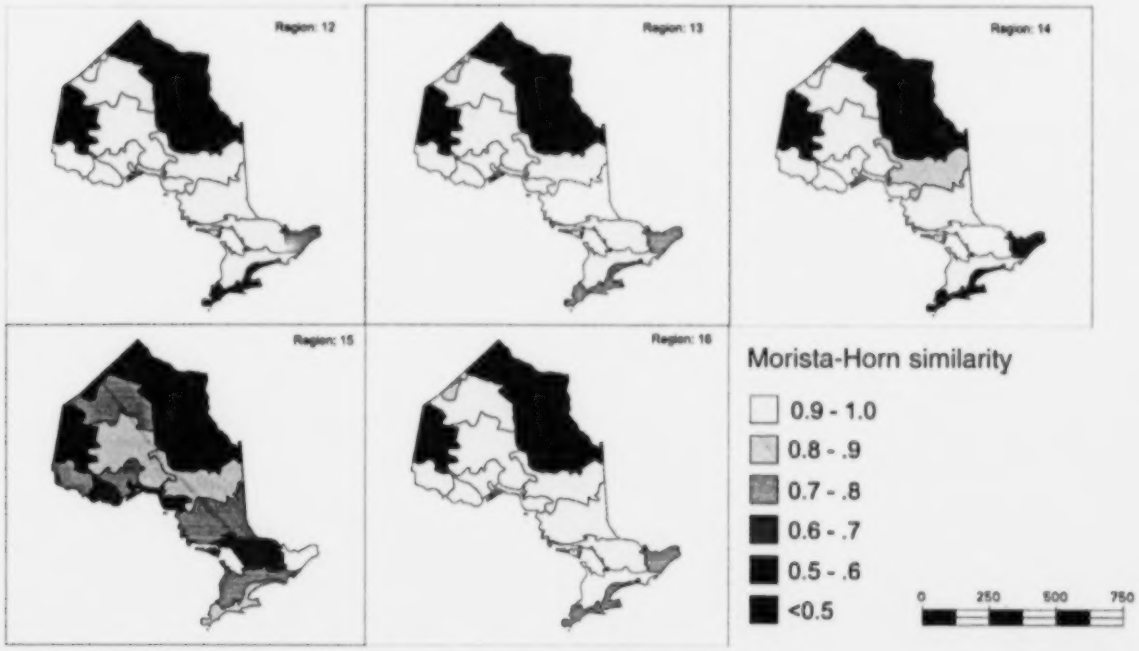
Morista-Horn similarity, RTEO System.



Morista-Horn similarity, RTEO System.



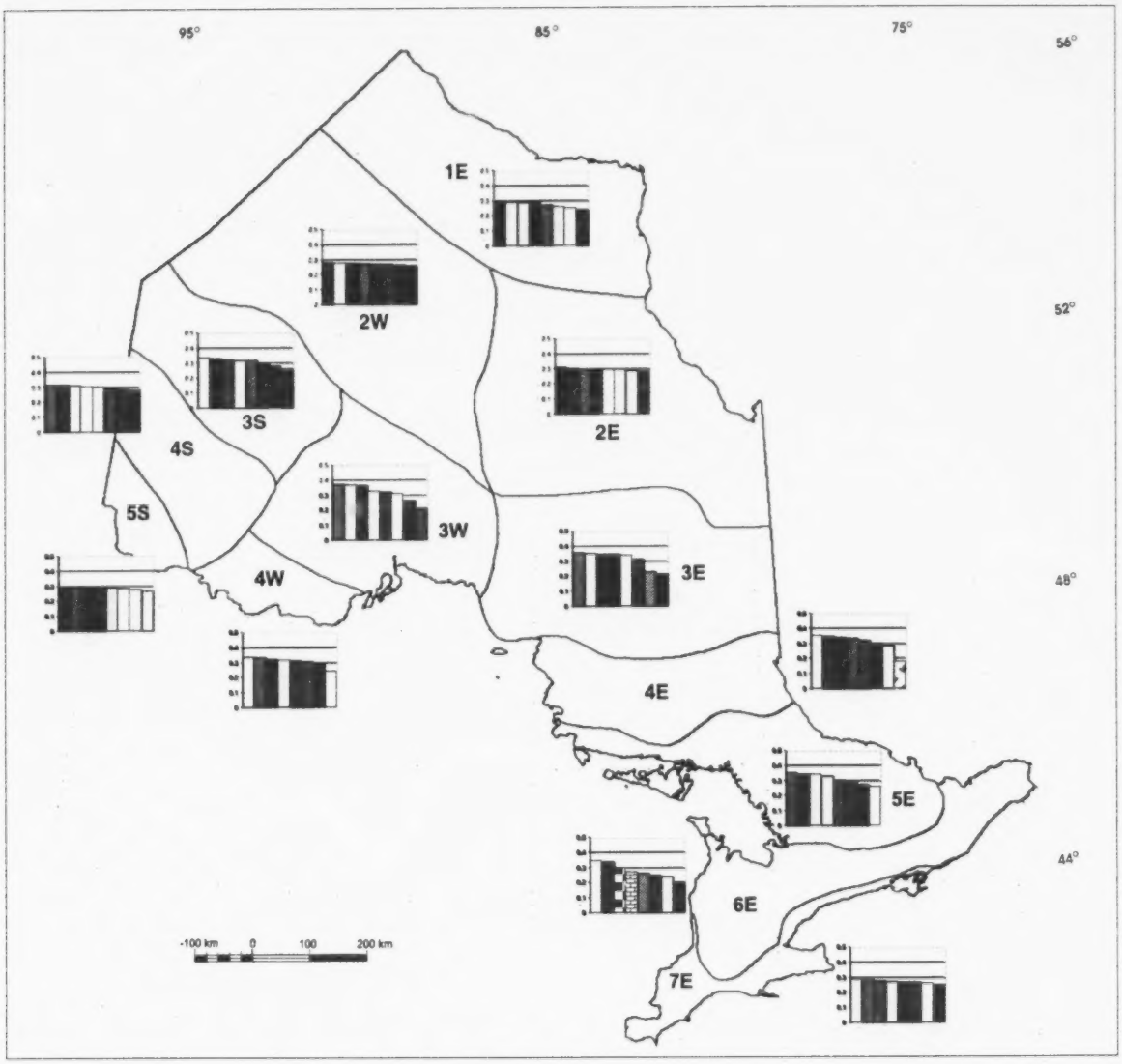
Morista-Horn similarity, TEO System.



Morista-Horn similarity, TEO System.

APPENDIX V

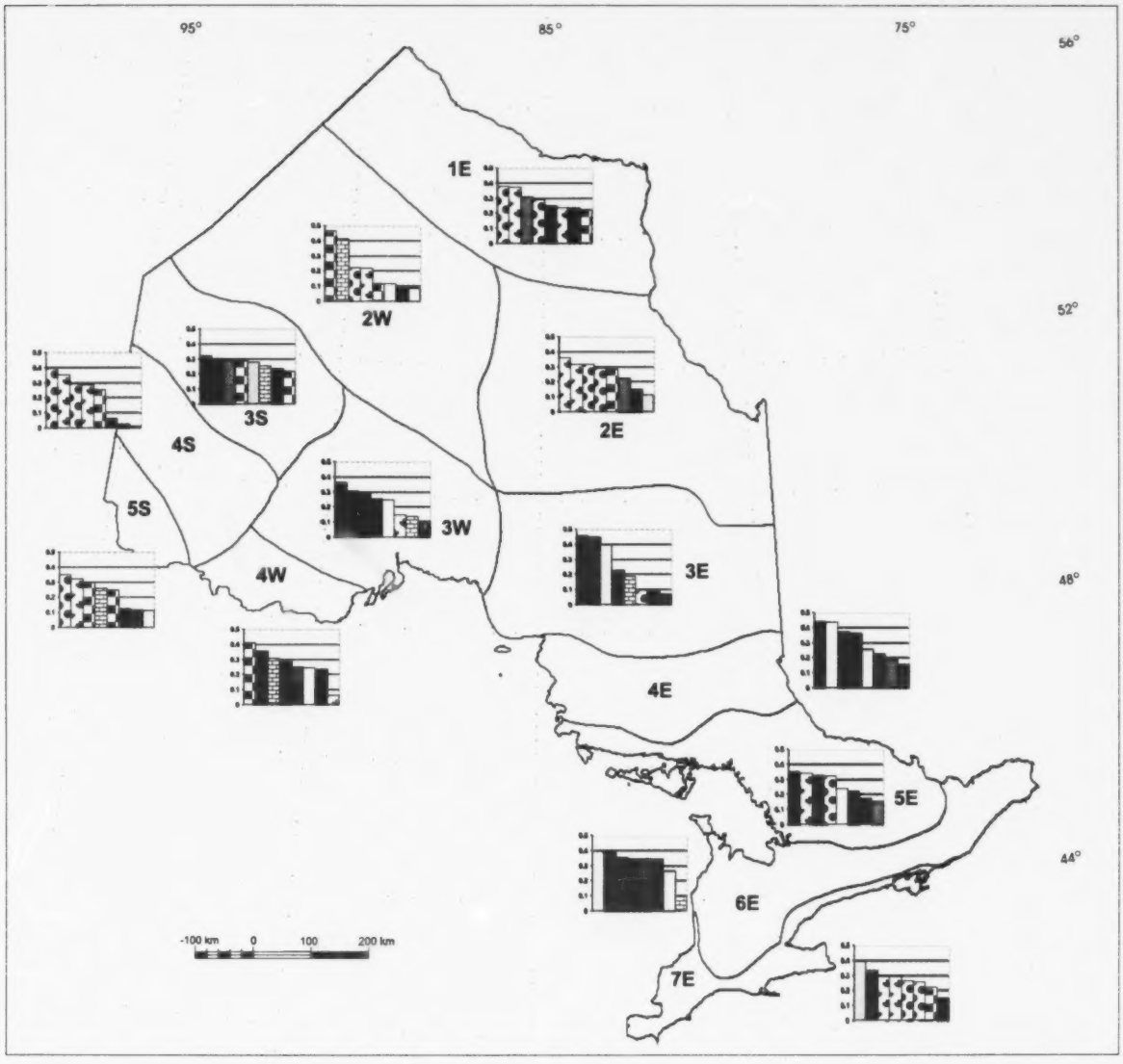
Principal Component Loading Maps



Variables

ANNPM	MAXJULY	ANNDD5	VG_SIM	GE_ED
JANPM	MINJAN	GROWLEN	VG_ED	GE_MPS
JULYPM	ANNTEMP	DEMBOUND	VG_MPS	GE_CON
ANNMAX	JANTEMP	KM1DEM	VG_CON	
ANNMIN	JULYTEMP	PSNRAW	GE_SIM	

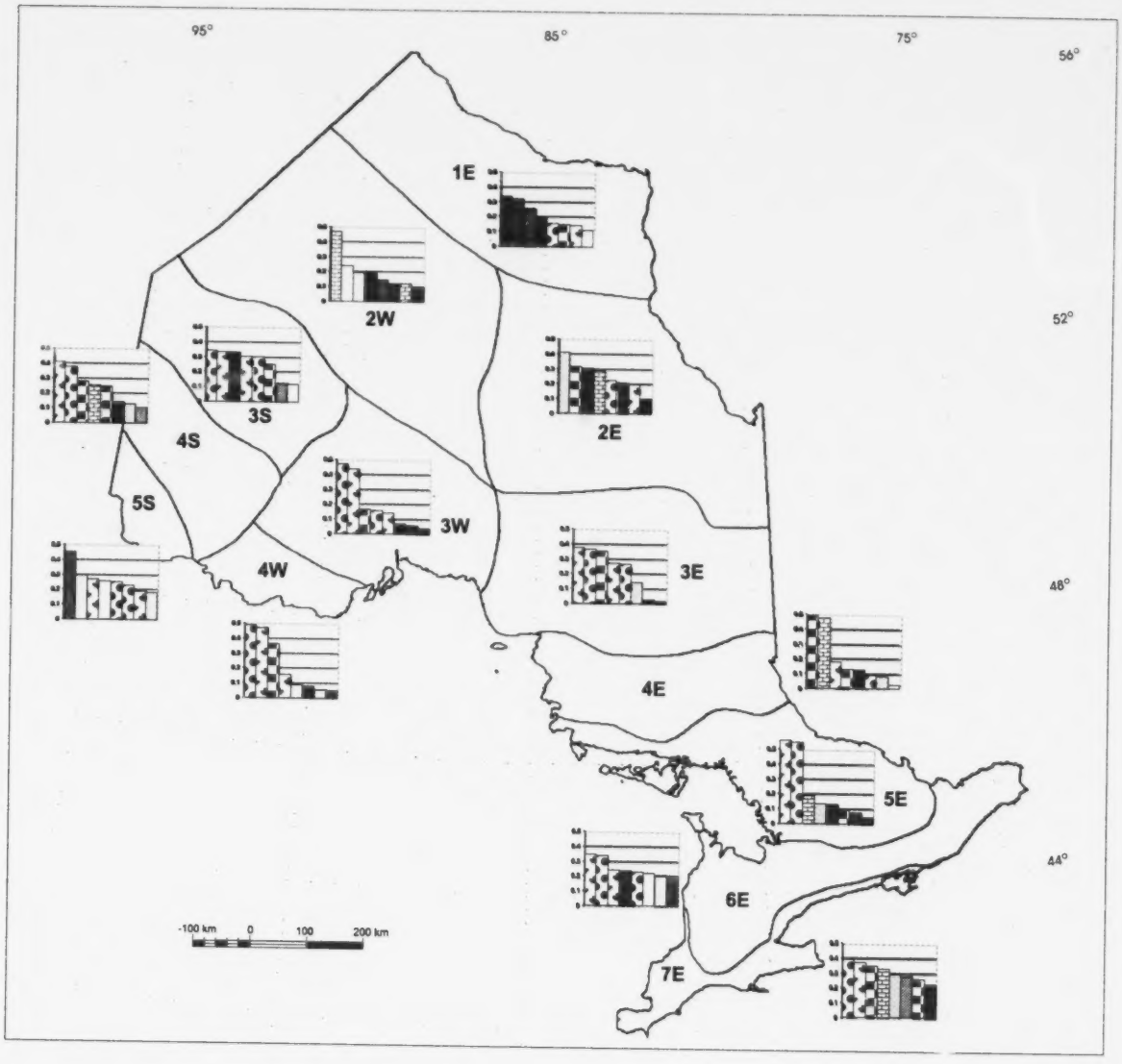
Eigenvector loadings of the 1st principal component by region, Hills System.



Variables

ANNPM	MAXJULY	ANNDD5	VG_SIM	GE_ED
JANPM	MINJAN	GROWLEN	VG_ED	GE_MPS
JULYPM	ANNTEMP	DEMBOUND	VG_MPS	GE_CON
ANNMAX	JANTEMP	KM1DEM	VG_CON	
ANNMIN	JULYTEMP	PSNRAW	GE_SIM	

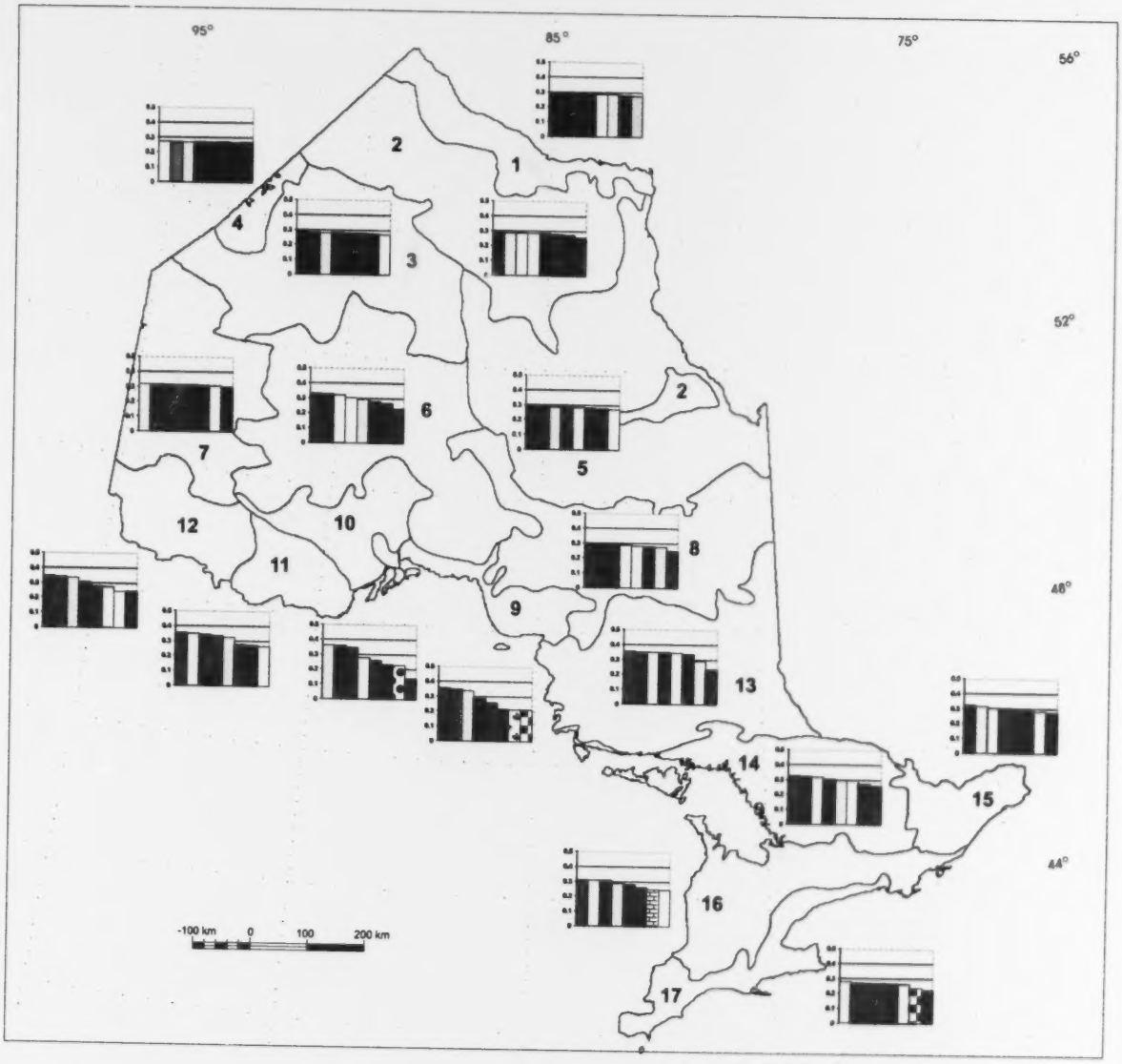
Eigenvector loadings of the 2nd principal component by region, Hills System.



Variables

ANNPM	MAXJULY	ANNDD5	VG_SIM	GE_ED
JANPM	MINJAN	GROWLEN	VG_ED	GE_MPS
JULYPM	ANNTEMP	DEMBOUND	VG_MPS	GE_CON
ANNMAX	JANTEMP	KM1DEM	VG_CON	
ANNMIN	JULYTEMP	PSNRAW	GE_SIM	

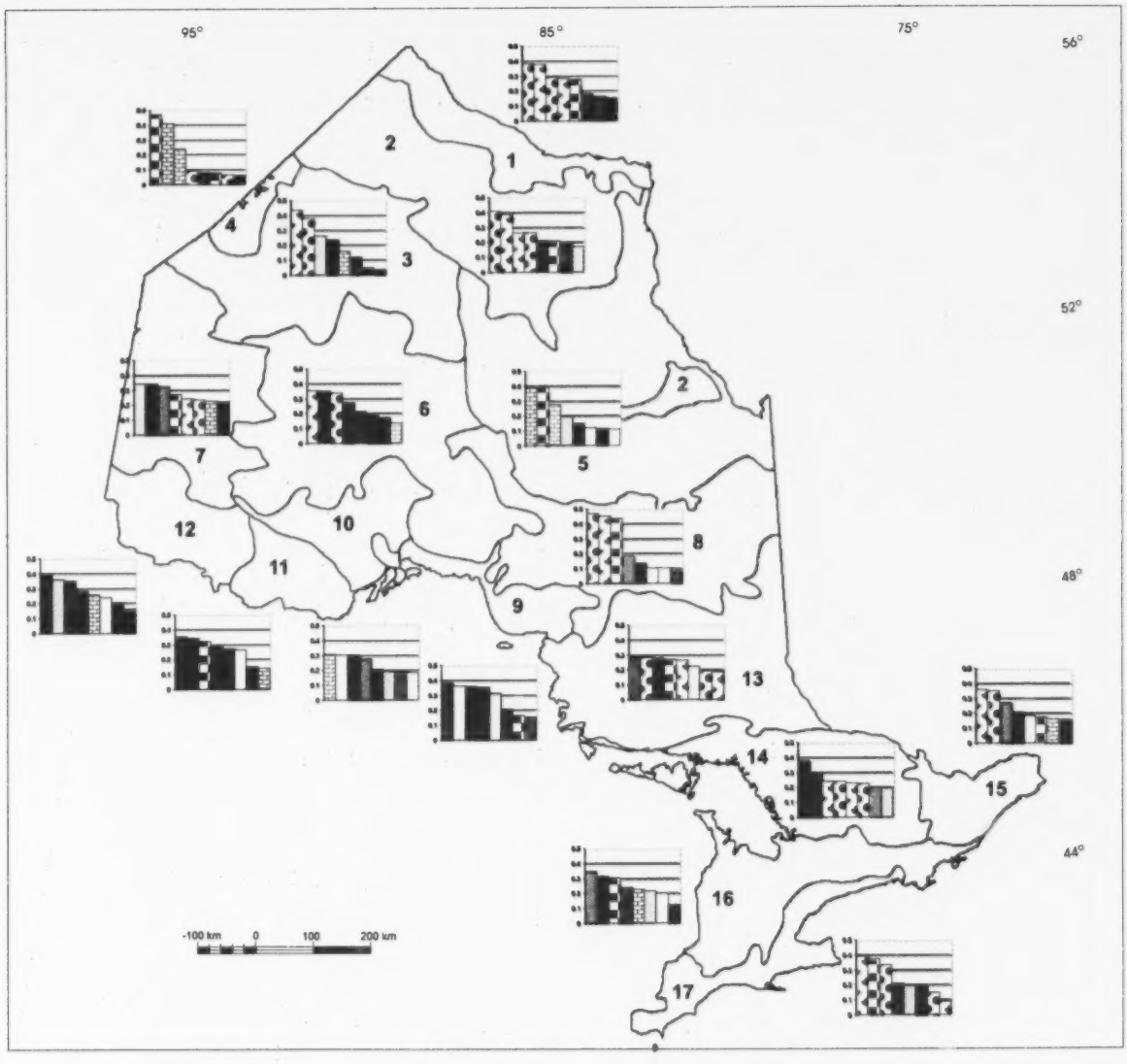
Eigenvector loadings of the 3rd principal component by region, Hills System.



Variables

ANNPM	MAXJULY	ANNDD5	VG_SIM	GE_ED
JANPM	MINJAN	GROWLEN	VG_ED	GE_MPS
JULYPM	ANNTEMP	DEMBOUND	VG_MPS	GE_C
ANNMAX	JANTEMP	KM1DEM	VG_CON	
ANNMIN	JULYTEMP	PSNRAW	GE_SIM	
	ON			

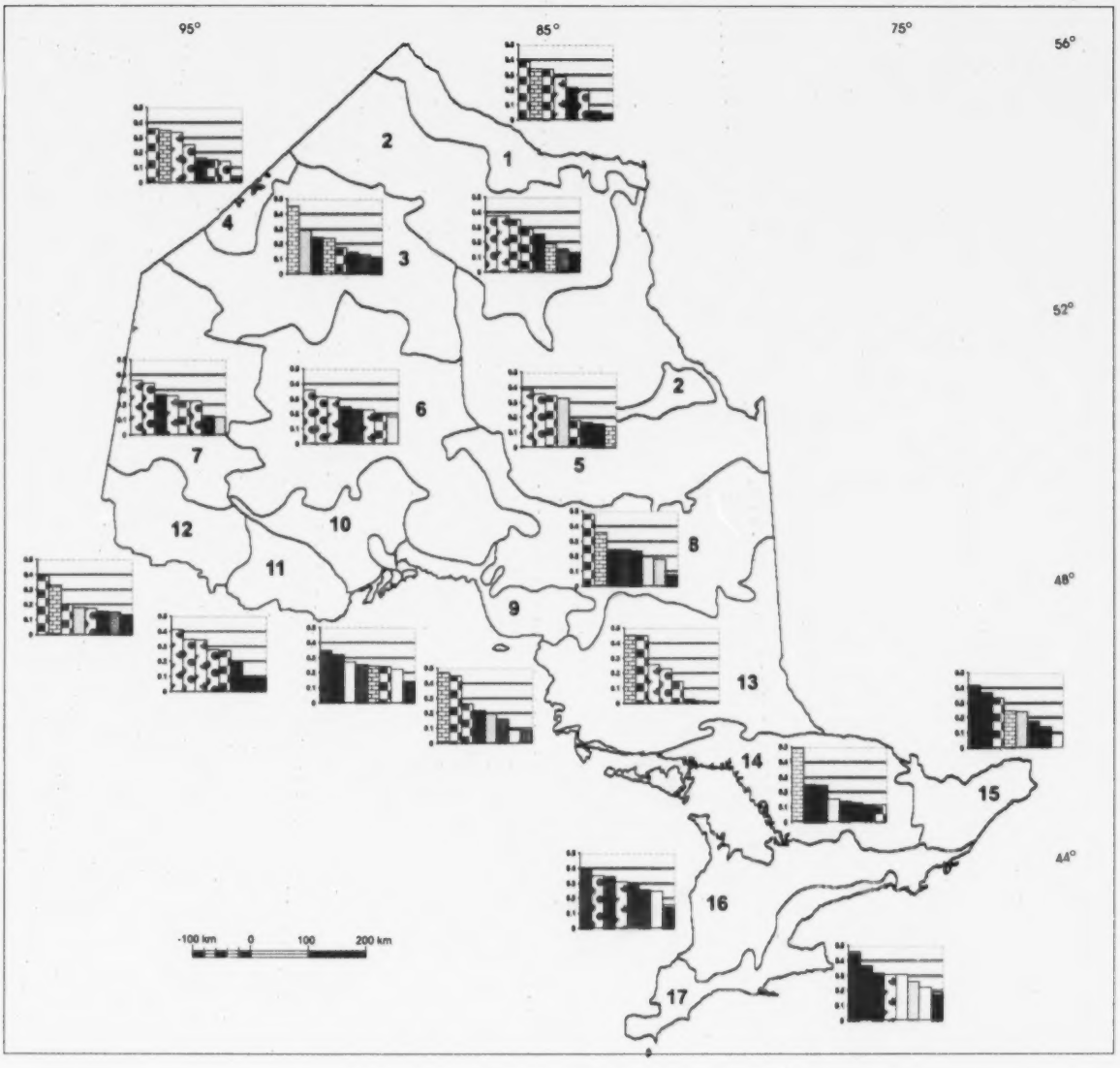
Eigenvector loadings of the 1st principal component by region, TEO System.



Variables

ANNPM	MAXJULY	ANNDD5	VG_SIM	GE_ED
JANPM	MINJAN	GROWLEN	VG_ED	GE_MPS
JULYPM	ANNTEMP	DEMBOUND	VG_MPS	GE_CON
ANNMAX	JANTEMP	KM1DEM	VG_CON	
ANNMIN	JULYTEMP	PSNRAW	GE_SIM	

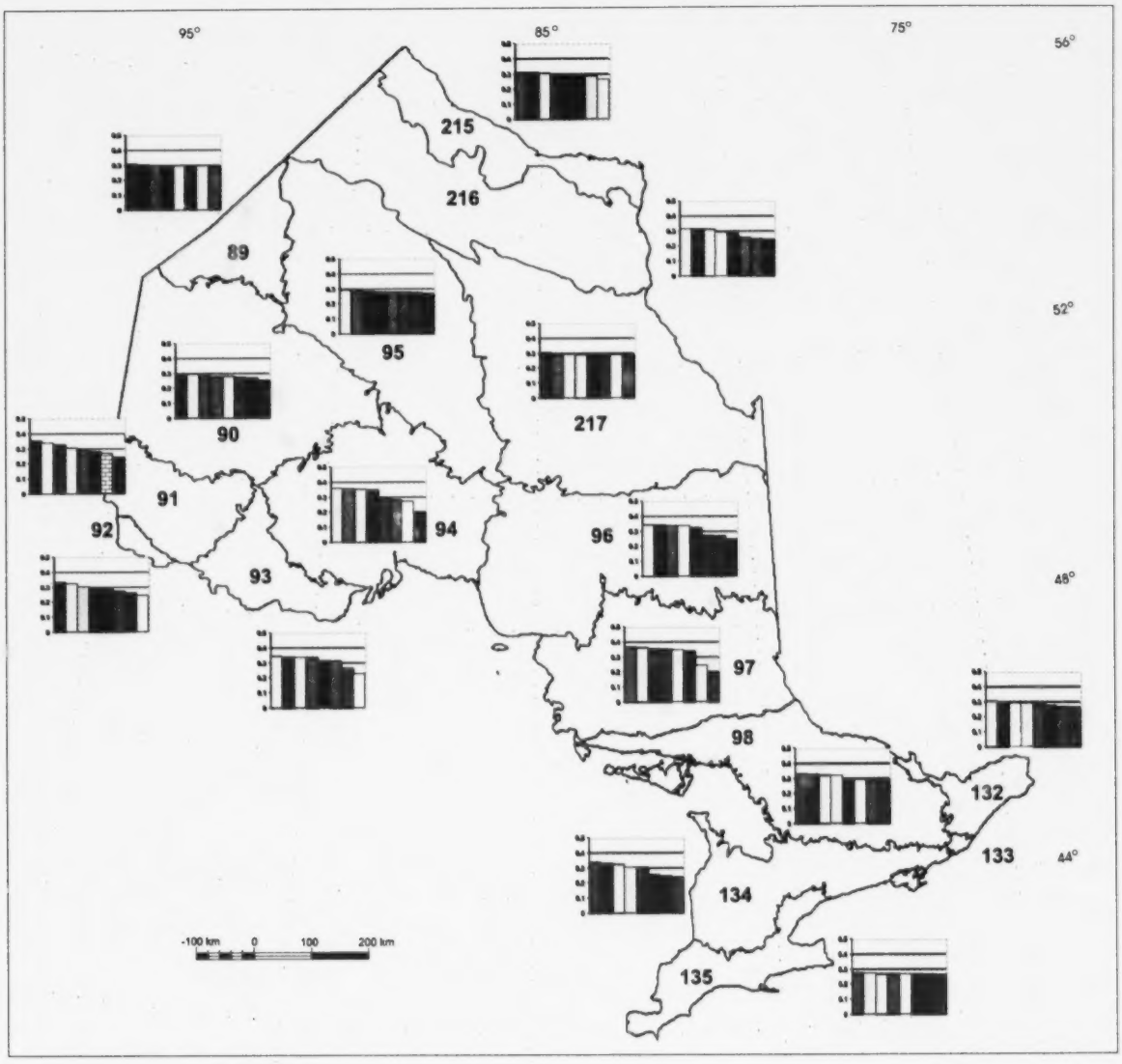
Eigenvector loadings of the 2nd principal component by region, TEO System.



Variables

ANNPM	MAXJULY	ANNDD5	VG_SIM	GE_ED
JANPM	MINJAN	GROWLEN	VG_ED	GE_MPS
JULYPM	ANNTEMP	DEMBOUND	VG_MPS	GE_CON
ANNMAX	JANTEMP	KM1DEM	VG_CON	
ANNMIN	JULYTEMP	PSNRAW	GE_SIM	

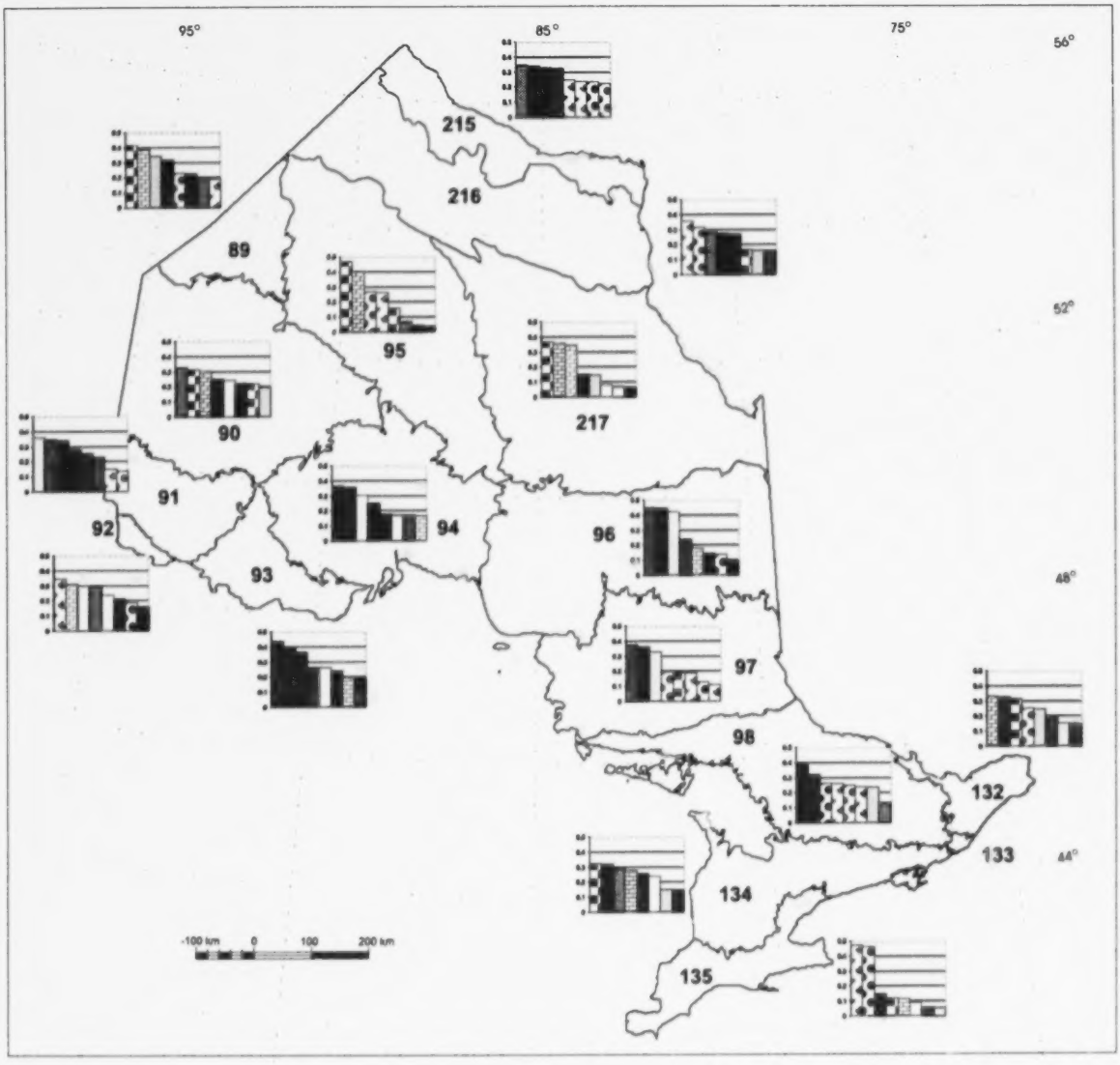
Eigenvector loadings of the 3rd principal component by region, TEO System.



Variables

ANNPM	MAXJULY	ANNDD5	VG_SIM	GE_ED
JANPM	MINJAN	GROWLEN	VG_ED	GE_MPS
JULYPM	ANNTEMP	DEMBOUND	VG_MPS	GE_CON
ANNMAX	JANTEMP	KM1DEM	VG_CON	
ANNMIN	JULYTEMP	PSNRAW	GE_SIM	

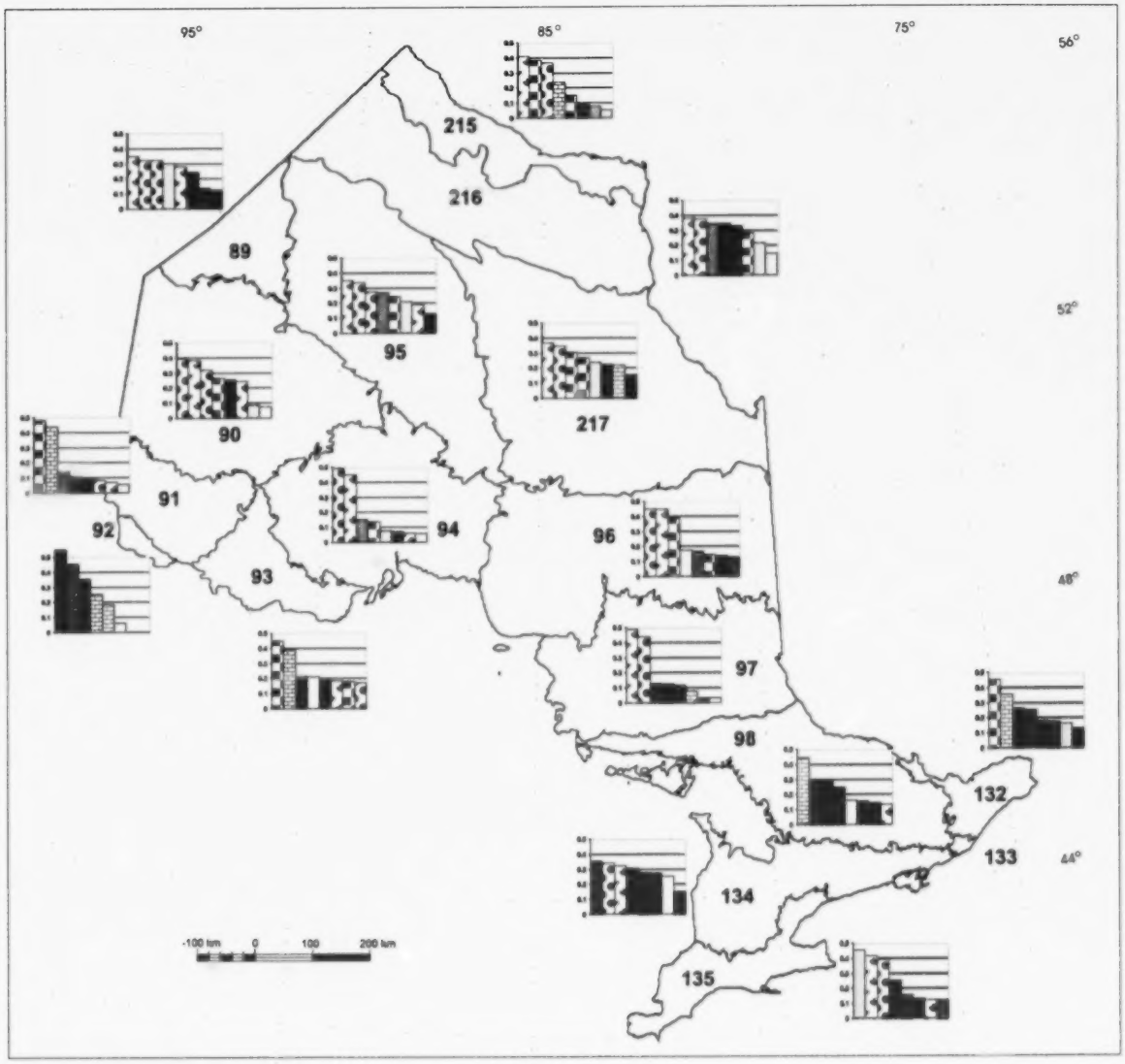
Eigenvector loadings of the 1st principal component by region, RTEO System.



Variables

ANNPM
JANPM
JULYPM
ANNMAX
ANNMIN
MAXJULY
MINJAN
ANNTEMP
JANTEMP
JULYTEMP
ANNDD5
GROWLEN
DEMBOUND
KM1DEM
PSNRAW
VG_SIM
VG_ED
VG_MPS
VG_CON
GE_SIM
GE_ED
GE_MPS
GE_CON

Eigenvector loadings of the 2nd principal component by region, RTEO System.



Variables

ANNPM	MAXJULY	ANNDD5	VG_SIM	GE_ED
JANPM	MINJAN	GROWLEN	VG_ED	GE_MPS
JULYPM	ANNTEMP	DEMBOUND	VG_MPS	GE_CON
ANNMAX	JANTEMP	KM1DEM	VG_CON	
ANNMIN	JULYTEMP	PSNRAW	GE_SIM	

Eigenvector loadings of the 3rd principal component by region, RTEO System.

APPENDIX VI

Boundary Analysis Summary

Summary of Boundary Analysis - Hills

Variable	2e3e	2w3s	2w3w	3e4e	3s4s	3w3e	3w3s	3w4s	3w4w	4e5e	4s4w	4s5s	5e6e	6e7e	Count	CountP	Score	ScoreA	Rank
ANNPM	2				2	2	2			3	3		2		8	0.57	17	1.21	10
JANPM						2		3			3	2	2		7	0.50	14	1.00	14
JULYPM			2	2			3				3				6	0.43	12	0.86	15
ANNMAX			2	2					2	3				2	10	0.71	16	1.14	11
ANNMIN					2	2			3	2	3	3	2	2	10	0.71	21	1.50	4
MAXJULY			2	2	2				3			2	2		9	0.64	16	1.14	11
MINJAN					2	2			3	2	2	3		2	12	0.86	21	1.50	4
ANNTEMP		2	2		2				3	3		2		2	11	0.79	20	1.43	6
JANTEMP			2		2	2			2	3		3		2	11	0.79	20	1.43	6
JULYTEMP				2					2	2	3	3	2	2	9	0.64	18	1.29	8
ANNDD5			2	2	2				3	2	2	3	2	2	12	0.86	23	1.64	2
GROWLEN				2					3	2		3		2	11	0.79	18	1.29	8
DEMBOUND							2					2	3		4	0.29	8	0.57	17
KM1DEM	2				3		3			3		3	2	3	10	0.71	22	1.57	3
PSNRAW	3		2											3	6	0.43	11	0.79	16
GEOLSIM	3	3			3		3		3	3			2	3	11	0.79	26	1.86	1
MULTIVAR	3						2			3	2	2		2	7	0.50	15	1.07	13
Count	8	9	11	12	13	8	9	7	10	13	11	14	16	13					
Score	16	12	18	18	24	13	18	9	27	32	24	33	26	28					
Rank	11	13	8	8	6	12	8	14	4	2	6	1	5	3					

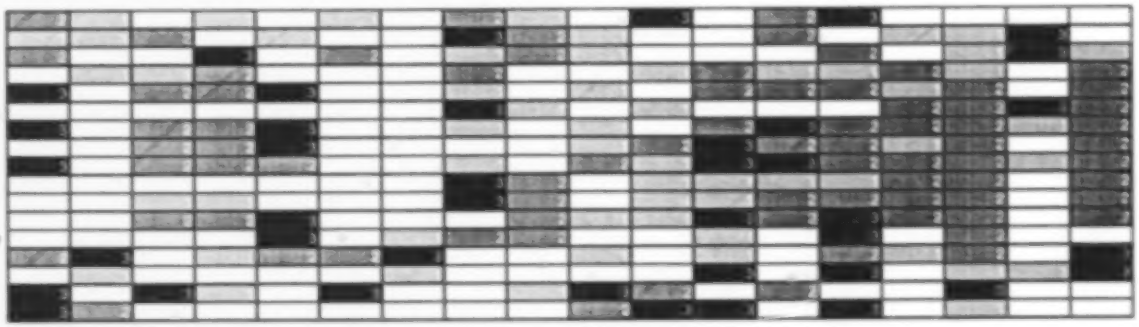
Ranking Scheme

3	Strong	Index >= 0.7	3
2	Med	Index >=0.6 < 0.7	2
	Weak	Index >=0.5 < 0.6	1
	None	Index < 0.5	0

Average Score: 21.2857

Curve shape also considered in rank
especially in GEOLSIM and MULTIVAR

Summary of Boundary Analysis - TEO



Variable	e3e6	e5e8	e6e7	e6e8	e6e9	e7e12	e8e13	e8e9	e9e10	e9e11	e9e13	e10e11	e11e12	e13e14	e14e15	e14e16	e15e16	e16e17	Count	CountP	Score	ScoreA	Rank
ANNPM	2							2			3		2	3					9	0.53	16	0.94	12
JANPM			2					3	2				2				3		11	0.65	18	1.06	9
JULYPM	2			3		2								2			1	2	10	0.59	18	1.06	9
ANNMAX				2				3				2		1	2			2	11	0.65	16	0.94	12
ANNMIN	3		2	2	3							2	2	2	1	2		2	12	0.71	23	1.35	4
MAXJULY								3							2	2	3	2	7	0.41	14	0.82	15
MINJAN	3		2	2	3							2	1	2	2	2		2	13	0.76	26	1.53	2
ANNTEMP			2	2	3						2	3	2	2	1	2		2	11	0.65	22	1.29	6
JANTEMP	3		2	2	2						2	3	1	2	2	2		2	14	0.82	28	1.65	1
JULYTEMP								3	2						2	2		2	9	0.53	15	0.88	14
ANNDD5								3	2			2	2	2	2	2		2	11	0.65	19	1.12	8
GROWLEN			2	2	3				2			3	2	3	2	2		2	12	0.71	25	1.47	3
DEMBOUND					3			2	2					3		2			7	0.41	14	0.82	15
KM1DEM	2	3				2	3					3		2	2	2			12	0.71	23	1.35	4
PSNRAW							2					3		3			2	2	7	0.41	13	0.76	17
GEOLSIM	3		3	2		3				3	2		2			3			9	0.53	21	1.24	7
MULTIVAR	3	2								2	3	3		3		2			7	0.41	17	1.00	11
Count	9	6	9	11	8	4	3	11	9	10	10	12	11	14	11	16	6	12					
Score	22	9	17	19	20	8	5	22	15	14	16	25	22	31	18	29	12	25					
Rank	5	16	11	9	8	17	18	5	13	14	12	3	5	1	10	2	15	3					

Ranking Scheme

	Strong	Index >= 0.7	3
	Med	Index >=0.6 < 0.7	2
	Weak	Index >=0.5 < 0.6	1
	None	Index < 0.5	0

Curve shape also considered in rank
especially in GEOLSIM and MULTIVAR

Average Score: 18.2222

Summary of Boundary Analysis - Hills

Variable	2e3e	2w3s	2w3w	3e4e	3s4s	3w3e	3w3s	3w4s	3w4w	4e5e	4s4w	4s5s	5e6e	6e7e	Count	CountP	Score	ScoreA	Rank
ANNPM										3	3				8	0.57	17	1.21	10
JANPM								3			3				7	0.50	14	1.00	14
JULYPM							3				3				6	0.43	12	0.86	15
ANNMAX										3					10	0.71	16	1.14	11
ANNMIN									3		3	3			10	0.71	21	1.50	4
MAXJULY									3						9	0.64	16	1.14	11
MINJAN									3			3			12	0.86	21	1.50	4
ANNTEMP									3	3					11	0.79	20	1.43	6
JANTEMP										3		3			11	0.79	20	1.43	6
JULYTEMP											3	3			9	0.64	18	1.29	8
ANNDD5									3			3			12	0.86	23	1.64	2
GROWLEN									3			3			11	0.79	18	1.29	8
DEMBOUND													3		4	0.29	8	0.57	17
KM1DEM					3		3			3		3		3	10	0.71	22	1.57	3
PSNRAW	3													3	6	0.43	11	0.79	16
GEOLSIM	3	3			3		3		3	3				3	11	0.79	26	1.86	1
MULTIVAR	3									3					7	0.50	15	1.07	13
Count	8	9	11	12	13	8	9	7	10	13	11	14	16	13					
Score	16	12	18	18	24	13	18	9	27	32	24	33	26	28					
Rank	11	13	8	8	6	12	8	14	4	2	6	1	5	3					

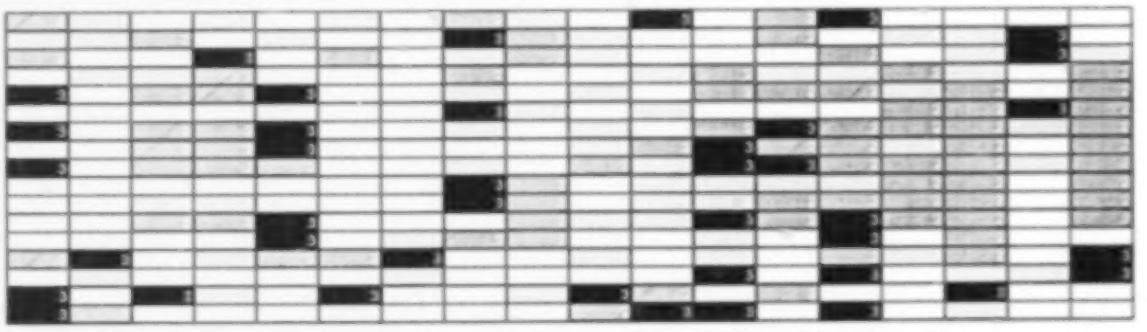
Ranking Scheme

3	Strong	Index >= 0.7	3
	Med	Index >=0.6 < 0.7	2
	Weak	Index >=0.5 < 0.6	1
	None	Index < 0.5	0

Curve shape also considered in rank
especially in GEOLSIM and MULTIVAR

Average Score: 21.2857

Summary of Boundary Analysis - TEO



Variable	e5e6	e5e8	e6e7	e6e9	e6e9	e7e12	e8e13	e8e9	e9e10	e9e11	e9e13	e10e11	e11e12	e13e14	e14e15	e14e16	e15e16	e16e17	Count	CountP	Score	ScoreA	Rank
ANNPM											3			3					9	0.63	16	0.94	12
JANPM								3									3		11	0.65	18	1.06	9
JULYPM				3													3		10	0.59	18	1.06	9
ANNMAX																			11	0.65	16	0.94	12
ANNMIN	3				3														12	0.71	23	1.35	4
MAXJULY								3									3		7	0.41	14	0.82	15
MINJAN	3				3								3						13	0.76	26	1.53	2
ANNTEMP					3							3							11	0.65	22	1.29	6
JANTEMP	3											3	3						14	0.82	28	1.65	1
JULYTEMP								3											9	0.53	15	0.88	14
ANNDDS								3											11	0.65	19	1.12	8
GROWLEN					3							3		3					12	0.71	25	1.47	3
DEMBOUND					3									3					7	0.41	14	0.82	15
KM1DEM		3					3											3	12	0.71	23	1.35	4
PSNRAW												3		3				3	7	0.41	13	0.76	17
GEOLSIM	3		3			3				3						3			9	0.53	21	1.24	7
MULTIVAR	3										3	3		3					7	0.41	17	1.00	11
Count	9	6	9	11	8	4	3	11	9	10	10	12	11	14	11	16	6	12					
Score	22	9	17	19	20	8	5	22	15	14	16	25	22	31	18	28	12	25					
Rank	5	16	11	9	8	17	18	5	13	14	12	3	5	1	10	2	15	3					

Ranking Scheme

3	Strong	Index >= 0.7	3
	Mod	Index >=0.6 < 0.7	2
	Weak	Index >=0.5 < 0.6	1
	None	Index < 0.5	0

Curve shape also considered in rank
especially in GEOLSIM and MULTIVAR

Average Score: 19.2222

Summary of Boundary Analysis - RTEO

Variable	j90j91	j90j94	j90j95	j91j93	j93j94	j94j95	j94j96	j95j217	j96j217	j96j97	j97j98	j98j132	j98j134	j134j135	Count	CountP	Score	ScoreA	Rank
ANNPM						3									7	0.50	13	0.93	14
JANPM								3							5	0.36	8	0.57	16
JULYPM	3														8	0.57	14	1.00	13
ANNMAX								3			3			3	11	0.79	21	1.50	9
ANNMIN		3				3	3							3	12	0.86	26	1.86	1
MAXJULY					3			3							9	0.64	18	1.29	12
MINJAN		3												3	12	0.86	22	1.57	8
ANNTEMP		3						3			3			3	12	0.86	26	1.86	1
JANTEMP		3		3				3			3			3	12	0.86	25	1.79	4
JULYTEMP					3	3					3			3	10	0.71	23	1.64	6
ANNDD5		3			3	3					3			3	12	0.86	26	1.86	1
GROWLEN		3									3			3	11	0.79	23	1.64	6
DEMBOUND	3									3					4	0.29	8	0.57	16
KM1DEM				3		3				3	3			3	10	0.71	25	1.79	4
PSNRAW				3						3		3	3		8	0.57	20	1.43	11
GEOLSIM			3				3	3				3	3		9	0.64	21	1.50	9
MULTIVAR															9	0.64	12	0.86	15
Count	14	9	8	10	11	9	13	14	7	11	14	13	16	12					
Score	21	23	13	21	23	20	24	33	14	18	32	26	30	33					
Rank	9	7	14	9	7	11	6	1	13	12	3	5	4	1					

Ranking Scheme

3	Strong	Index >= 0.7	3
	Med	Index >=0.6 < 0.7	2
	Weak	Index >=0.5 < 0.6	1
	None	Index < 0.5	0

Curve shape also considered in rank
especially in GEOLSIM and MULTIVAR

Average Score: 23.6429

Summary of Boundary Analysis - RTEO

Variable	j90j91	j90j94	j90j95	j91j93	j93j94	j94j95	j94j96	j95j217	j96j217	j96j97	j97j98	j98j132	j98j134	j134j135	Count	CountP	Score	ScoreA	Rank
ANNPM						3		2	2	2	2				7	0.50	13	0.93	14
JANPM								3	2		1				5	0.36	8	0.57	16
JULYPM	3	2			2			2	2	1					8	0.57	14	1.00	13
ANNMAX			2	1	2			3		1	3	2	2	3	11	0.79	21	1.50	9
ANNMIN	1	3		2	2	3	3	2		1	2	2	2	3	12	0.86	26	1.86	1
MAXJULY	2				3		2	3			2	1	2	2	9	0.64	18	1.29	12
MINJAN		3		2		1	2	2		1	2	2	2	3	12	0.86	22	1.57	8
ANNTEMP		3	2	2	2		2	3		1	3	2	2	3	12	0.86	26	1.86	1
JANTEMP		3		3			2	3		1	3	2	2	3	12	0.86	25	1.79	4
JULYTEMP	2	2		1	3	3	2				3	2	2	3	10	0.71	23	1.64	6
ANNDD5		3		2	3	3	2	1			3	2	2	3	12	0.86	26	1.86	1
GROWLEN		3		2	2		2	2			3	2	2	3	11	0.79	23	1.64	6
DEMBOUND	3									3			1		4	0.29	8	0.57	16
KM1DEM			2	3		3		2	2	3	3	2	2	3	10	0.71	25	1.79	4
PSNRAW	2			3	2				2	3		3	3	2	8	0.57	20	1.43	11
GEOLSIM			3			2	3	3	2	1	1	3	3		9	0.64	21	1.50	9
MULTIVAR						1	1	2	2		1	1	1	2	9	0.64	12	0.86	15
Count	14	9	8	10	11	9	13	14	7	11	14	13	16	12					
Score	21	23	13	21	23	20	24	33	14	18	32	26	30	33					
Rank	9	7	14	9	7	11	6	1	13	12	3	5	4	1					

Ranking Scheme

3	Strong	Index >= 0.7	3
2	Med	Index >=0.6 < 0.7	2
1	Weak	Index >=0.5 < 0.6	1
	None	Index < 0.5	0

Curve shape also considered in rank
especially in GEOLSIM and MULTIVAR

Average Score: 23.6429

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